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NAVIGATION CONDITIONS AT COLUMBUS LOCK AND DAM, TOMBIGBEE RIVER--ETC(U)
MAY 77 J J FRANCO, L J SHOWS

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TECHNICAL REPORT H-77-11

NAVIGATION CONDITIONS AT COLUMBUS LOCK AND DAM, TOMBIGBEE RIVER MISSISSIPPI AND ALABAMA

Hydraulic Model Investigation

by

J. J. Franco, L. J. Shows

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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The Columbus Lock and Dam will be the third navigation structure proposed as part of the development of the Tennessee-Tombigbee Waterway for navigation. The structure will be located in a bypass canal about 370 miles above the mouth of the Mobile River at the foot of Government Street in Mobile, Alabama, or just downstream from the confluence of the Tombigbee and Tibbee Rivers and about 4 miles northwest of Columbus in Lowndes County, Mississippi. The structure is designed to maintain a minimum upper pool during low flows extending upstream

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20. ABSTRACT (Continued).

to the proposed Aberdeen Lock and Dam at mile 408 and will include one lock with clear chamber dimensions of 110 by 600 ft, a five-gate spillway section of the dam located in the bypass canal on the left overbank, and a fixed overflow section along the left overbank to high ground. A fixed-bed model reproducing about 4.5 miles of the Tombigbee River channel, upper and lower lock approaches, the lock approach canal, and the adjacent overbank areas to an undistorted scale of 1:120 was used to determine the adequacy of the proposed plan and to develop modifications required to eliminate any adverse conditions indicated. The model investigation was concerned principally with navigation conditions into and within the lock approach canal and in the lock approaches and the distribution of flow through the gated section of the dam. Results of the investigation revealed that navigation conditions in the upper approach with the original plan would be difficult and hazardous during the higher flows but that satisfactory conditions could be developed by modifications within the upper lock approach and the construction of properly designed dikes along the approach canal to eliminate or reduce crosscurrents. Even with the modifications developed, two-way navigation in the upper approach to the lock could be difficult and hazardous during high flows and with a flood on the Tibbee River and little or no flow in the Tombigbee River. No navigation difficulties were indicated in the lower lock approach with any of the plans tested. Distribution of flow through the gated spillway was affected by the offset between the lock and right abutment of the dam but could be improved by placing a fillet between the two structures. Satisfactory navigation conditions into and out of the lower reach of the Tibbee River could be developed for limited size tows but conditions would tend to be difficult and hazardous during the higher flows.

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers, in an indorsement dated 18 December 1972 to the Division Engineer, U. S. Army Engineer Division, South Atlantic, Atlanta, Georgia. The study was conducted in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) during the period January 1973 to September 1974.

The investigation was conducted under the general supervision of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, and Mr. F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory; and under the direct supervision of Messrs. J. J. Franco (retired) and J. E. Glover, former and present Chiefs of the Waterways Division. The engineer in immediate charge of the model was Mr. L. J. Shows, Chief of the Navigation Branch, assisted by Messrs. R. T. Wooley and J. L. McGregor. This report was prepared by Messrs. Shows and Franco.

During the course of the model study, Messrs. Wayne Odom, A. F. Baer, Bobby Felder, and Fred Thompson of the U. S. Army Engineer District, Mobile, visited WES at different times to observe special model tests and discuss the results. The Mobile District was kept informed of the progress of the study through monthly progress reports and special reports at the end of each test.

Directors of WES during the course of the investigation and the preparation and publication of this report were BG E. D. Peixotto, CE; COL G. H. Hilt, CE; and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U. S. statute)	1.609	kilometres
square miles	2.589	square kilometres
acres	4046.856	square metres
feet per second	0.3048	metres per second
cubic feet per second	0.02831	cubic metres per second
acre-feet	1233.482	cubic metres

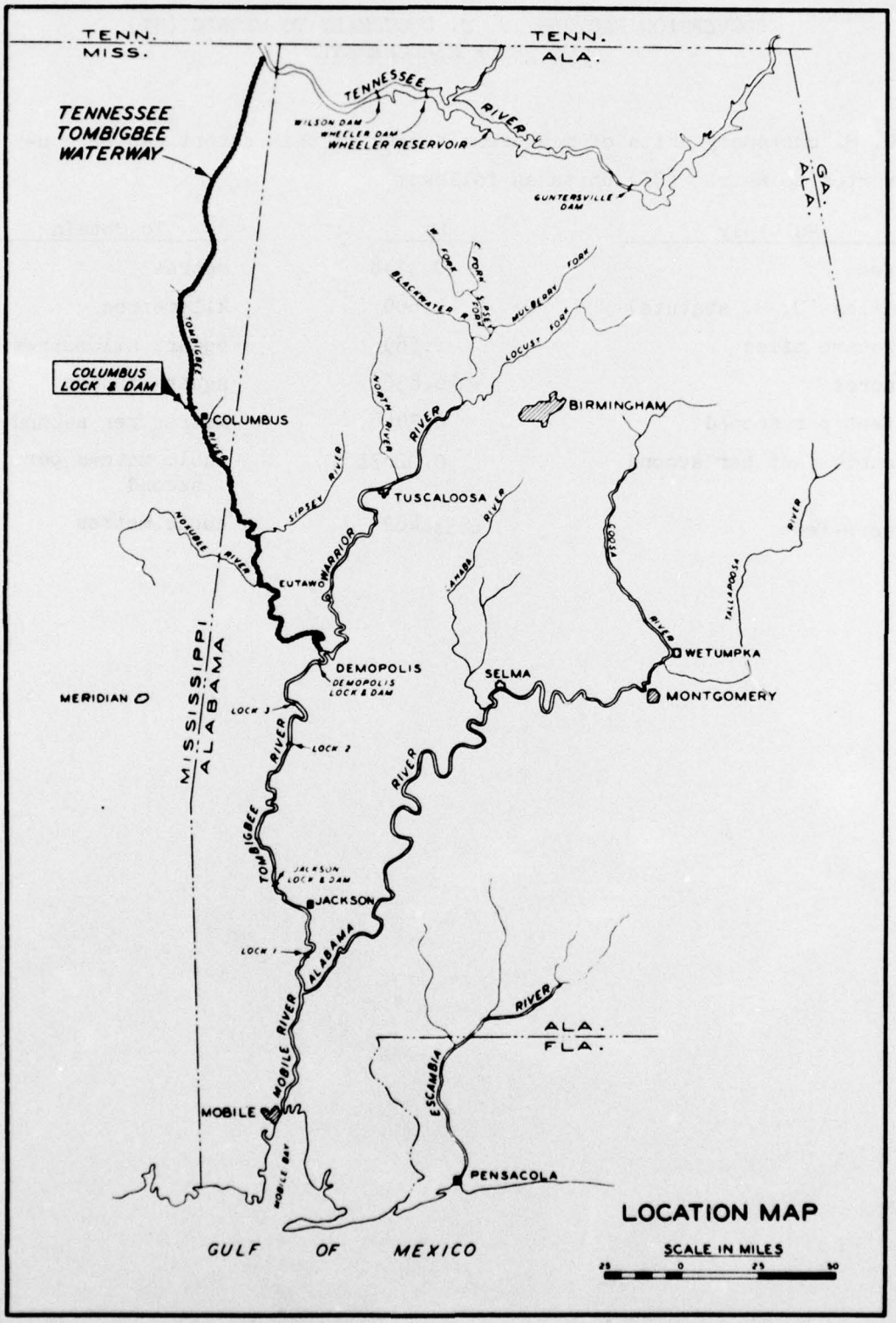

Figure 1. Vicinity map

NAVIGATION CONDITIONS AT COLUMBUS LOCK AND DAM, TOMBIGBEE RIVER, MISSISSIPPI AND ALABAMA

Hydraulic Model Investigation

PART I: INTRODUCTION

Location of Proposed Lock and Dam and Description of Prototype*

1. The Columbus Lock and Dam is to be constructed in northeast Mississippi on the Tombigbee River about 149 miles** above its confluence with the Warrior River and about 36 miles above the proposed Aliceville Dam site. The lock and dam will be the third navigation structure on the Tennessee-Tombigbee Waterway above the Demopolis Lock and Dam, which is at the confluence of the Warrior and Tombigbee Rivers. The proposed site for the Columbus Dam is about 4 miles northwest of Columbus in Lowndes County, Mississippi, (Figure 1), at river mile 370.15 above the mouth of the Mobile River at the foot of Government Street, Mobile, Alabama. The structures are designed to maintain during low flow a single upper pool extending upstream to the proposed Aberdeen Lock and Dam at mile 408.

2. The Tombigbee River above Columbus Dam has a drainage area of 4470 square miles (which is approximately 85 miles long with an average width of about 50 miles). The river lies entirely within the coastal plain with elevations† ranging from about 1000 ft at the highest point to 126 ft at the damsite. The Tombigbee River is formed by the junction of the east and west forks and flows 59 miles nearly due south to the Columbus Dam site.

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* Prototype information was obtained from Columbus Lock and Dam Design Memorandum Nos. 1 and 2, dated June and November 1972, respectively.

** A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

† Elevations (el) cited herein are in feet referenced to mean sea level (msl).

3. The ridge separating the Tennessee River from the headwaters of the Tombigbee is about 15 miles south of the Tennessee River in extreme northeast Mississippi. The ridge divides the waters of Yellow Creek, which flows northward into the Tennessee River, from the waters of Mackeys Creek, which flows southward to the east fork of the Tombigbee. The Tennessee-Tombigbee project as proposed will cut a channel through this divide to el 395 and connect these rivers for navigation by means of locks and dams. At low stages the Tombigbee River varies in width from 75 ft at its source to 400 ft at Demopolis. The principal tributaries of the Tombigbee River above the proposed Columbus Lock and Dam are the east and west forks which form the stream and the Tibbee River just upstream.

Present Plan of Improvement and Development

4. The Tennessee-Tombigbee project, first authorized in the 1946 River and Harbor Act, consists of three reaches: the river section, the canal section, and the divide section. The river section will consist of a 173.04-mile-long reach of river that will extend up the Tombigbee River from Demopolis, Alabama, to a point just north of Amory, Mississippi, and will involve straightening the river channel and building conventional locks and dams near Gainesville and Aliceville, Alabama, and Columbus and Aberdeen, Mississippi. The canal section will consist of a 45.6-mile-long canal that will parallel the Tombigbee River on the east and will be separated from the river by levees from near Amory to Mackeys Creek near Old Bay Springs in the southwest corner of Tishomingo County, Mississippi. It will involve excavating a canal and constructing levees with five locks. The divide section will consist of a 39.3-mile-long canal that will extend from Bay Springs, Mississippi, to the Yellow Creek arm of Pickwick Lake on the Tennessee River near the common boundary of Mississippi, Alabama, and Tennessee, and will involve a 27-mile-long cut through the divide separating the Tombigbee and Tennessee Basins. The river section will be 9 ft deep and the canal and divide sections will be 12 ft deep. The bottom width will be 300 ft,

except in the actual divide cut where it will be 280 ft. The lock chambers will be 110 ft wide by 600 ft long and will have a depth of 15 ft over the miter gate sills, corresponding to the new locks on the connecting waterways. The locks will provide a total lift of 341 ft to overcome the difference between the elevations of Demopolis Lake on the Tombigbee River and Pickwick Lake on the Tennessee River.

5. The major portion of the prospective commerce consists of upbound movement of commodities which are normally moved in bulk. Virtually all the upbound commerce originates in the immediate trade areas of the Gulf ports or at industries or producing areas along the Gulf Intracoastal Waterway. Upbound traffic originating at New Orleans or west thereof would terminate generally along the upper Tennessee River; traffic originating at Mobile or ports to the east, because of the greater distance advantage in comparison with that of the Mississippi River, would be distributed over a much broader area along the Ohio and the upper Mississippi Rivers and their tributaries. Similarly, a large part of the downbound traffic would terminate along the Gulf Coast or be exported through the ports of Mobile or New Orleans. Shippers and receivers along the Warrior River, principally Tuscaloosa and Birmingham, would also contribute an appreciable volume of traffic to the waterway.

Description of Proposed Structures

6. The general design of Columbus Lock and Dam provides for a navigation lock, a concrete-gated spillway, and a system of overflow and nonoverflow access roads. The structures will provide a normal upper pool at el 163 with a normal lift of 27 ft in the lock chamber from Aliceville pool at el 136. The lock will be constructed in a bypass canal excavated in the left or east river bank. An abutment wall will connect the east side of the lock and the gated spillway, which will consist of a concrete sill with five tainter gates. A concrete abutment wall will connect the spillway to an earth mound to the east which has been designated for public use purposes. A 9600-ft-long overflow earth-fill dike will extend eastward from the mound to connect

to high ground. A nonoverflow earth-fill dike connected to the earth mound adjacent to the west side of the lock will extend north across the Old River channel and tie into high ground along the right bank. A culvert in the dike will provide a continuous flow of fresh water into the Old River channel in the Plymouth Bluff area. In addition to the lock and dam structures, an approach canal will extend about 9000 ft upstream of the dam axis on the right overbank and about 3300 ft downstream on the left overbank. At normal pool el 163.0, the reservoir will extend 38 miles upriver to the Aberdeen Lock and Dam. The pool, which will have an area of 9000 acres and a total volume of 74,000 acre-ft, will be used exclusively for navigation and recreational purposes.

Need for, Scope, and Purpose of Model Study

7. The general design of Columbus Lock and Dam was based on sound theoretical design practice and experience with similar structures. However, since navigation conditions vary with location and flow conditions upstream and downstream of a structure, an analytical study to determine the hydraulic effects that can reasonably be expected to result from a particular design is both difficult and inconclusive. Conditions in the general area of Columbus Lock and Dam were especially complicated by the location of the approach canal with respect to the river channel, overbank flow, and flow from the Tibbee River. Thus, a comprehensive model study was considered necessary to investigate conditions that could be expected with the proposed design and to develop modifications required to ensure satisfactory navigation conditions.

8. The locations of the lock and dam just downstream from the mouth of the Tibbee River near Plymouth Bluff and the lock approach canal were fixed at the time the model study was undertaken. Therefore, the specific purpose of the model study was to determine the adequacy of the proposed design for navigation and the discharge distribution at the dam with various river flows and to develop modifications that might be required to eliminate any undesirable conditions. The model

was also used to demonstrate to navigation interests the conditions resulting from the proposed design and to satisfy these interests of its acceptability from a navigation standpoint.

PART II: THE MODEL

Description

9. The model (Figure 2) reproduced about 4.5 miles of the Tombigbee River, extending from just downstream of the lock and dam to just upstream of the entrance to the lock approach canal. Also included were the lock, the upper and lower lock approaches, the gated and fixed crest sections of the dam, about 2.2 miles of the Tibbee River, a cutoff canal about 2.33 miles long, and the adjacent overbank areas. The model was of the fixed-bed type with the channel and overbank areas molded in sand-cement mortar to sheet metal templets. Portions of the model, where changes in bank alignments and channel configurations could be anticipated, were molded in pea gravel to permit modifications that might be required to provide satisfactory conditions. The lock, dam, crest, and piers were fabricated of sheet metal. The dam gates were simulated schematically with simple sheet metal slide-type gates.

10. The model was molded to hydrographic and topographic surveys made in December 1971 and March 1972, respectively. Overbank areas were molded to a maximum elevation of 168 on the left and 210 on the right insofar as conditions would permit and based on the need for the reproduction and investigation of flows that would affect navigation.

Scale Relations

11. The model was built to an undistorted linear scale ratio of 1:120 model-to-prototype to obtain accurate reproduction of velocities, crosscurrents, and eddies that would affect navigation. Other scale ratios resulting from the linear scale ratio were as follows:

Area	1:14,400
Velocity	1:10.95
Time	1:10.95
Discharge	1:157,743
Roughness (Manning's n)	1:2.22

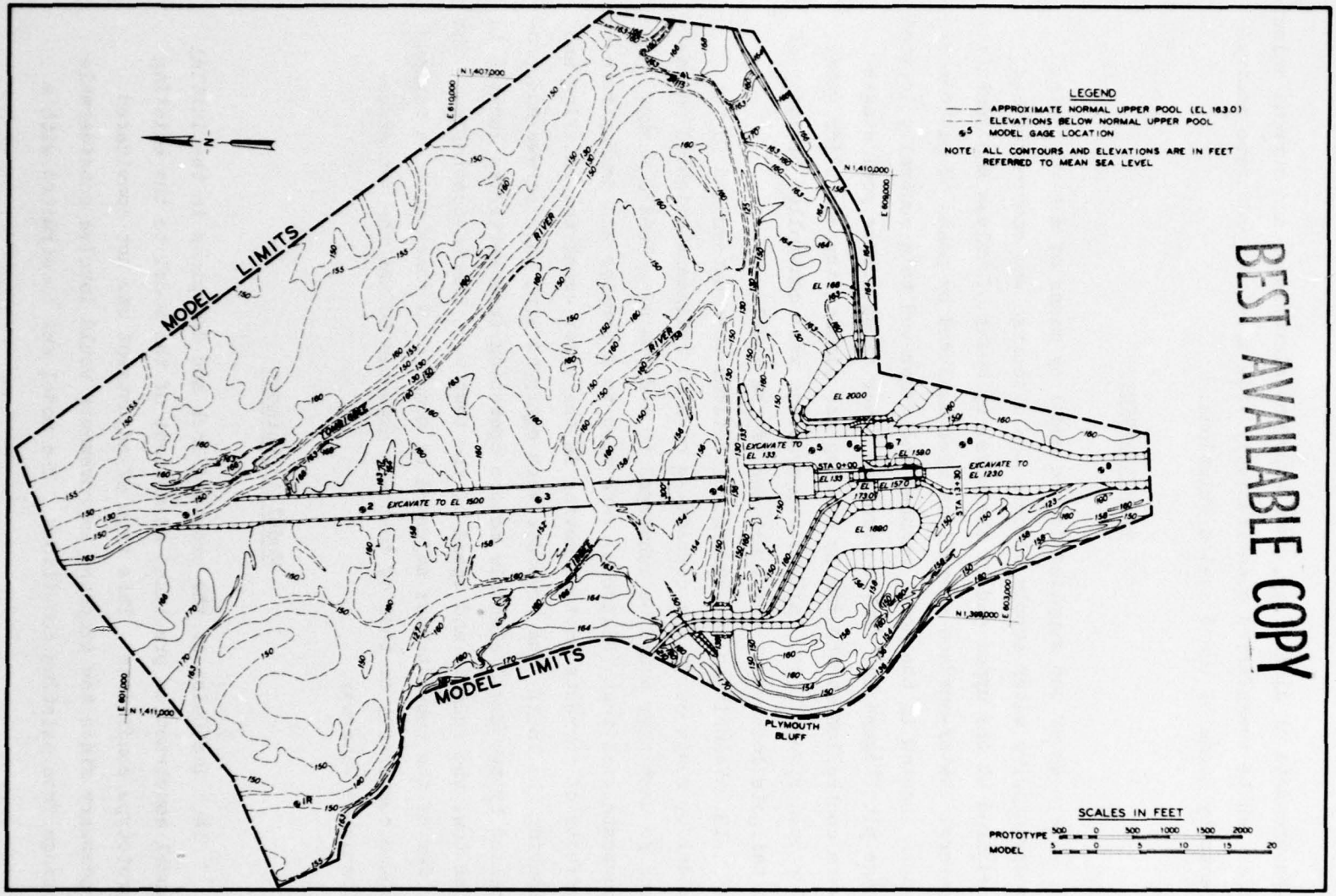

Figure 2. Model layout and location of gages

Measurements of discharges, water-surface elevations, and current velocities can be transferred quantitatively from model to prototype equivalents by means of these scales relations.

Appurtenances

12. Water was supplied to the model by means of a circulating comprehensive water supply system; the discharge was controlled and measured at the upper end of the model by means of valves and venturi meters. Water-surface elevations were measured by means of piezometer gages located in the model channel and connected to a centrally located gage pit (Figure 2). For controlled river flows, upper pool stages were controlled at the dam by opening and closing the dam slide gates; for open river flows, tailwater elevations were controlled by means of a tailgate located at the lower end of the model.

13. Velocities and current directions were determined in the model by means of floats consisting of wood cylinders weighted on one end so that they would be submerged to a depth of a loaded barge. Model towboats with tows (Figure 3) were used to determine and demonstrate the effects of currents on tows moving in the upper canal and entering and leaving the lock. The towboats were equipped with twin screws and propelled by two small electric motors operating from batteries located in the tow; the rudders and speed of the tows were remote-controlled. The power of the towboats was adjusted by means of a rheostat to a maximum speed comparable to that of towboats expected to use the Tennessee-Tombigbee Waterway.

Model Adjustment

14. Inclusion of the proposed lock and dam plans in the initial model construction precluded adjustment of the model to the existing prototype conditions. This type of adjustment was not considered necessary since the proposed improvements would involve considerable change from existing conditions. The model was constructed with a

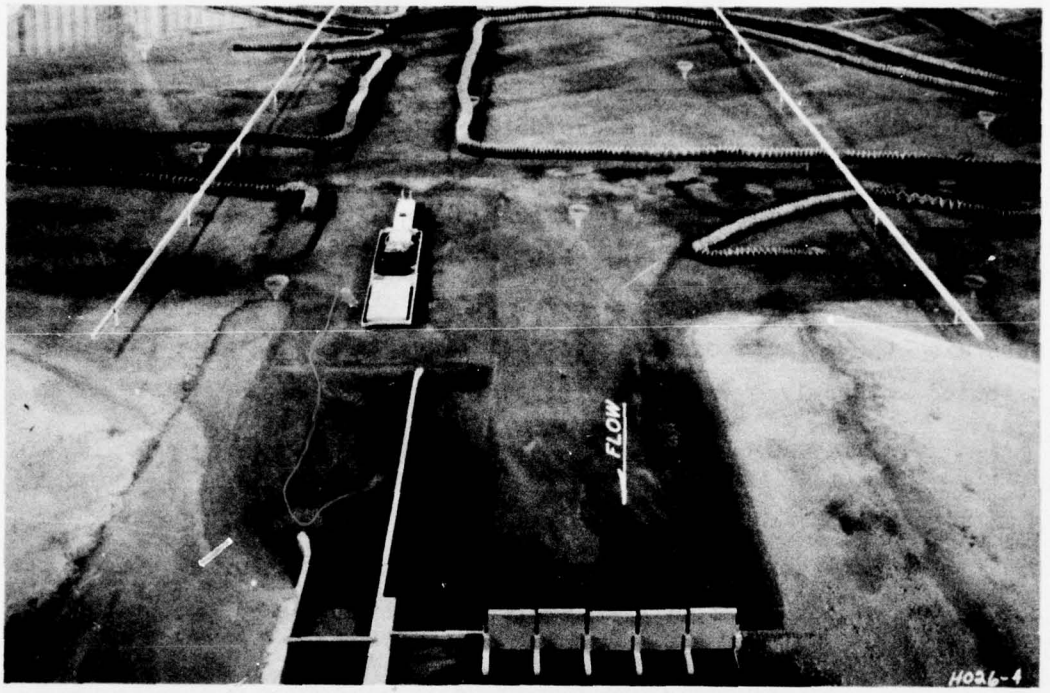

Figure 3. Remote-controlled towboat and tow approaching the proposed lock

brushed cement-mortar finish to provide a roughness factor (Manning's n) of about 0.0135, which corresponds to a prototype channel roughness of about 0.030. Experience with other models of this type has indicated that brushed concrete gives a very close approximation of the roughness required to reproduce prototype conditions.

PART III: TESTS AND RESULTS

15. Tests in the model were concerned primarily with the study of flow patterns, measurements of velocities, swell head at the dam, and the behavior of the model tow in the lock approaches and the cutoff canal approaching the lock for various river flows. Since the worst conditions for navigation were obtained in the model during the higher river stages with uncontrolled river flows, no tests were conducted to determine the effects of dam gate operation other than with flow distributed uniformly over the entire length of the dam.

Test Procedures

16. Tests were conducted by reproducing the following stages and discharges with the computed tailwater elevations based on information furnished by the Mobile District:

a. A controlled river flow of 30,000 cfs with normal upper pool elevation of 163.0 (30 percent of the total flow from the Tibbee River).

b. Maximum flow at which normal upper pool elevation of 163.0 could be maintained (57,000 cfs), with 36 percent of the flow from the Tibbee River.

c. An intermediate flow (115,000 cfs) with tailwater elevation of 168.7, with 35.2 percent of the flow from the Tibbee River.

d. Maximum navigable flow (180,000 cfs) with tailwater elevation of 171.6, with 35 percent of the flow from the Tibbee River.

e. Maximum flow at normal upper pool elevation (same as subparagraph b above) with all the flow (57,000 cfs) from the Tibbee River. This condition assumed a flood on the Tibbee River with little or no flow in the Tombigbee River and was used in tests of two of the plans.

17. The controlled river flow was reproduced by introducing the proper discharge, setting the tailwater elevation for the discharge, and manipulating the dam gate openings until the required upper pool elevation was obtained. Uncontrolled river flows were reproduced by introducing the proper discharge with dam gates fully open and

manipulating the tailgate to obtain the proper tailwater elevation below the dam. All stages were permitted to stabilize before data were recorded. Current directions were determined by plotting the paths of wooden floats described in paragraph 13 with respect to ranges established for that purpose, and velocities were measured by timing the travel of the floats over known distances. General surface current directions were determined by time-exposure photographs recording the movement of paper confetti on the water surface. No data were obtained with the model tows other than observations of their behavior in the lock approaches and moving through the upper canal. Flow distributions along the length of the dam were based on velocity measurements through each gate bay.

18. Most of the modifications were developed during preliminary tests. Data obtained during these tests were sufficient only to assist in the development of plans that appeared to produce the improvements desired. Results of the preliminary tests are not included in this report.

Original Design

Description

19. The original plan proposed for the lock and dam and the approaches to the lock is shown in Figures 4 and 5 and included the following principle features:

a. A nonnavigable gated spillway and lock were located in a cutoff canal in the left overbank near Plymouth Bluff. The lock located along the right bank had clear chamber dimensions of 110 ft wide by 600 ft long, a 600-ft-long ported upper guard wall, and a 600-ft-long nonported lower guard wall with the top of the lock walls at el 173.0. The spillway contained five 60-ft-wide gate bays and six 8-ft-wide piers with gate sills at el 138.0

b. A 142-ft-long abutment wall with a top elevation of 173.0 extended from the spillway to the left bank and the public use area. An overflow dike and service road about 9600 ft long with a top elevation of 168.0 extended from the public use area (el 200.0) to high ground on the left overbank. The model reproduced only about one half of

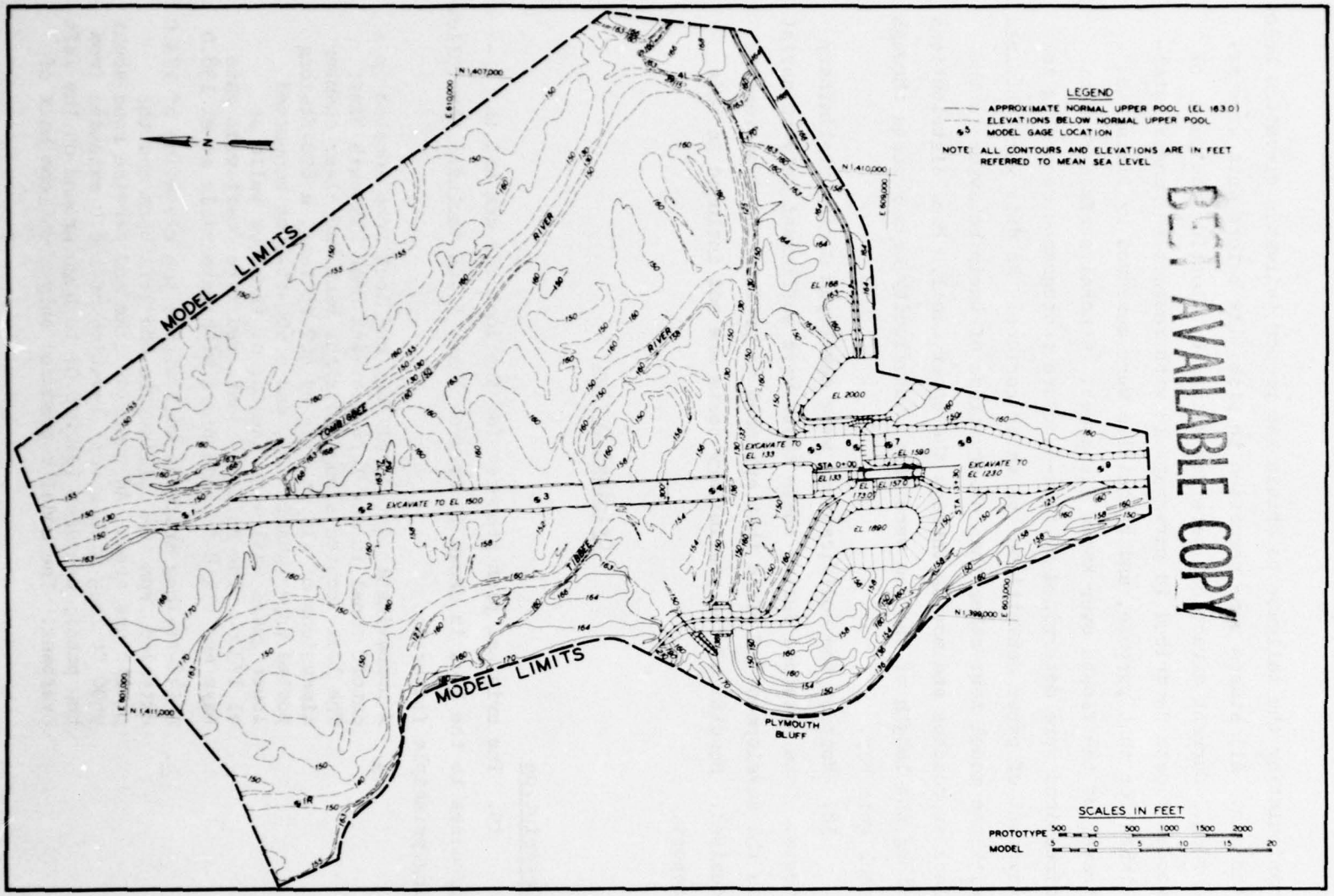

Figure 4. Original plan for lock and dam

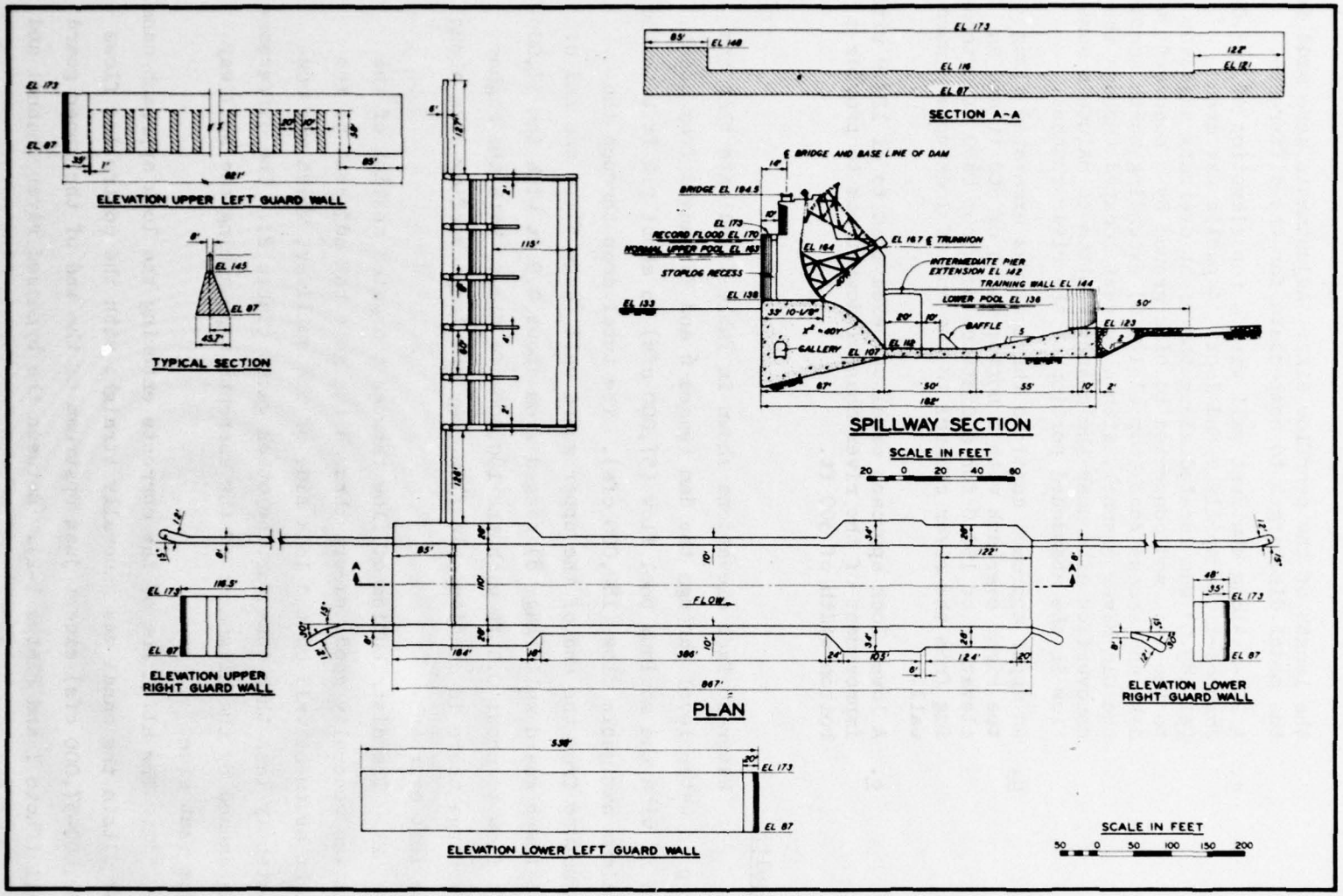

Figure 5. General plan and sections

the length of the overflow dike. Adjustments were made in the model discharges to compensate for the difference.

c. A 200-ft-long abutment wall with a top elevation of 173.0 connected the spillway and lock. A public use area (el 189.0) was located along the right overbank adjacent to the lock and connected to high ground by a nonoverflow dike and access road (top el 189.0) extending north across the Old River channel, with a culvert located through the nonoverflow dike near the channel bottom to maintain some flow in the abandoned portion of the river channel.

d. An upper approach canal to the lock was excavated along the right overbank with a bottom width of 300 ft and an elevation of 150.0 for a distance of about 8400 ft extending from the river channel to the end of lock upper guard wall.

e. A lower lock approach canal was excavated to el 123.0 with improvement of the river channel downstream to provide a bottom width of 300 ft.

Results

20. Water-surface elevations shown in Table 1 indicate that the drop in water level through the dam (gages 6 and 7) ranged from about 0.5 ft with the maximum pool flow (57,000 cfs) to about 0.2 ft with the maximum navigable flow (180,000 cfs). The total drop through the structure from the end of the upper guard wall (gage 5) to the end of the lower guard wall (gage 8) ranged from about 0.9 ft with the 57,000-cfs flow to about 0.4 ft with the 180,000-cfs flow. With the higher discharge there is considerable flow over the long overflow dike along the left overbank.

21. The distribution of flow through the gated section of the dam was generally good, except through the gate bay adjacent to the right abutment wall on the lock side of the spillway, which was consistently less than that for the other gates (Table 2). The difference was caused by the alignment of the currents approaching the spillway from that side.

22. The alignment of the currents entering the lock approach canal and within the canal was generally straight with the controlled flows (30,000-57,000 cfs) except just upstream of the end of the upper guard wall (Photo 1 and Plates 1-2). Between the bypassed river channel and

the end of the upper guard wall, most of the flow moved to the left out of the lock approach channel. Velocities of the currents moving to the left out of the lock approach varied from a maximum of about 1.8 fps with the 30,000-cfs flow to about 3.8 fps with the 57,000-cfs flow. The alignment and velocity of currents with the uncontrolled river flows (115,000-180,000 cfs) were affected by flow from the right overbank moving toward the left across most of the upper reach of the lock approach canal (Plates 3 and 4). In the lower reach of the canal, currents were reasonably straight except in the lock approach upstream of the end of the upper guard wall where practically all of the flow from the canal moved to the left toward the spillway. Most of the flow from the right overbank moved toward the upper guard wall. Maximum velocities of the currents moving to the left out of the lock approach channel varied from about 2.3 to 3.4 fps with the higher velocities obtained with the lower flow (115,000 cfs). Velocities within the approach canal were moderate and considerably less with the controlled flows.

23. In the lower approach to the lock, currents moved from the spillway side of the channel toward the right bank diagonally across the lock approach (Photo 2, Plates 1-4). A clockwise eddy formed along the right bank just downstream of the end of the lower guard wall. Velocities of currents moving across the lower approach to the lock varied from about 2.4 to about 4.4 fps with the higher velocity obtained with the 57,000-cfs flow.

24. No serious navigation difficulties were indicated in the approach canal or in the approach to the upper guard wall with the controlled river flows. Navigation in the canal and in the approach to the lock during the higher flows was affected by currents moving from the right overbank across the canal and to the left toward the spillway upstream of the upper guard wall. Currents moving across the canal would make it difficult for tows to maintain proper alignment and tows would be in danger of hitting the left bank. The difficulty would increase with increase in river stages. No difficulties were indicated for tows entering or leaving the lower lock approach with any of the

flows tested. Velocities in the eddy in the lower approach were too low to have any serious adverse effect on the movement of tows under reasonable control.

Plans A and A-1

Description

25. Plan A was developed in an effort to improve the alignment of currents and navigation conditions in the lock approach canal during the higher flows. This plan was the same as the original design except for an earth dike about 4400 ft long with a top elevation of 178.0 placed along the left bank of the canal between its upstream end and the Tibbee River channel (Figure 6).

26. Plan A-1 was developed to eliminate adverse navigation conditions observed during the test of plan A for downbound tows entering the canal. This plan was the same as plan A except for an earth-fill dike about 2475 ft long with a top elevation of 178.0 placed along the right bank of the canal near the upstream end of the canal (Figure 7).

Results

27. Results shown in Table 3 indicate little or no difference in water-surface elevation between plans A and A-1 or between these plans and the original design. The drop in water level through the dam (gages 6 and 7) ranged from about 0.4 ft with the maximum pool flow to about 0.2 ft with the high flow. The total drop in water levels through the structure (gages 5-8) was about 0.9 ft with the maximum pool flow (57,000 cfs), about 0.8 ft with the intermediate flow (115,000 cfs), and about 0.4 with the higher flow (180,000 cfs).

28. The results of tests with plan A (Plate 5) indicate considerable improvement in the alignment of the currents within the lower reach of the approach canal over those observed with the original design. However, near the upper entrance, currents moved across the canal and in some cases upstream toward and into the river channel, particularly during the higher flows. With plan A-1 currents from the right overbank moved across the entrance to the approach canal and across the

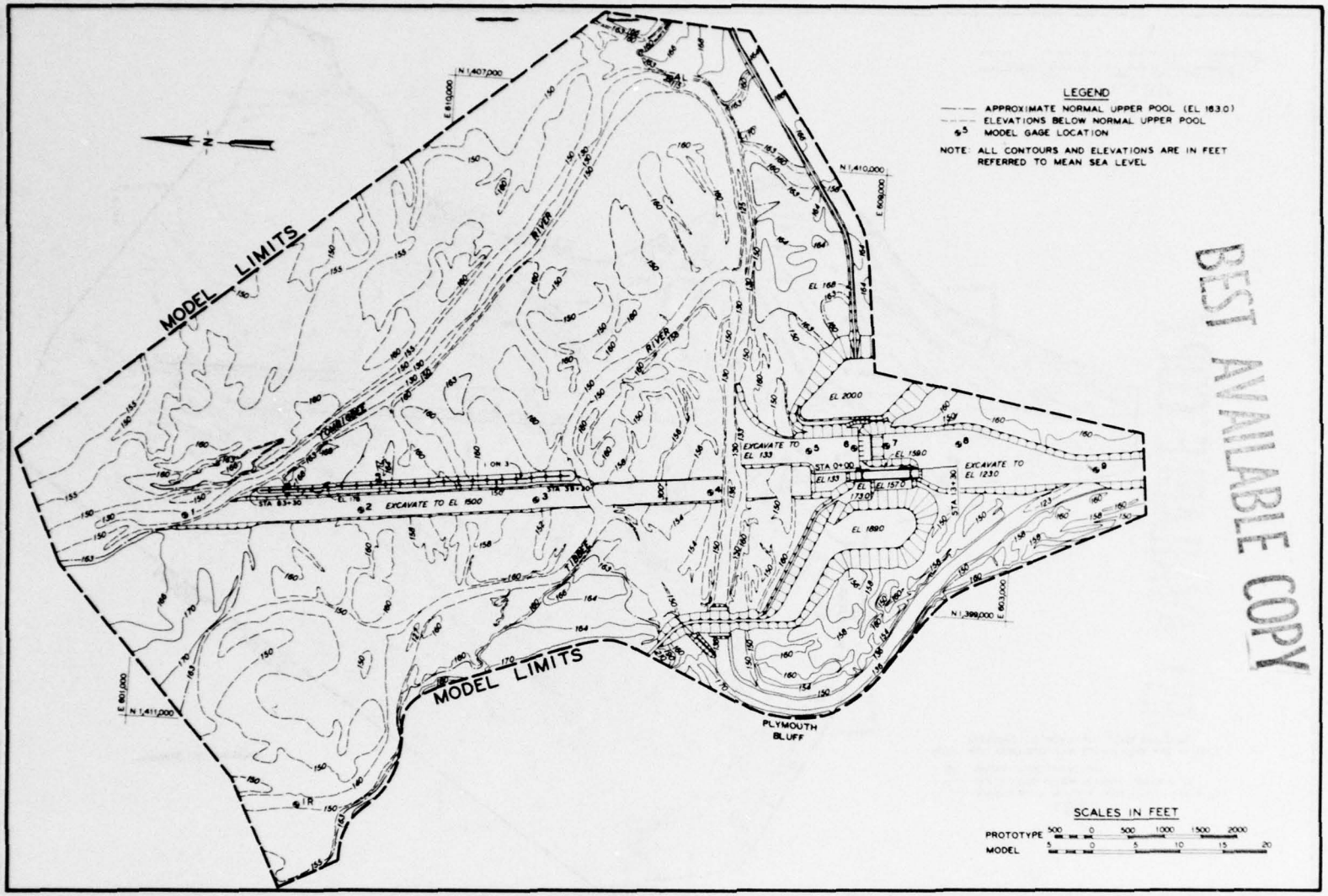

Figure 6. Plan A

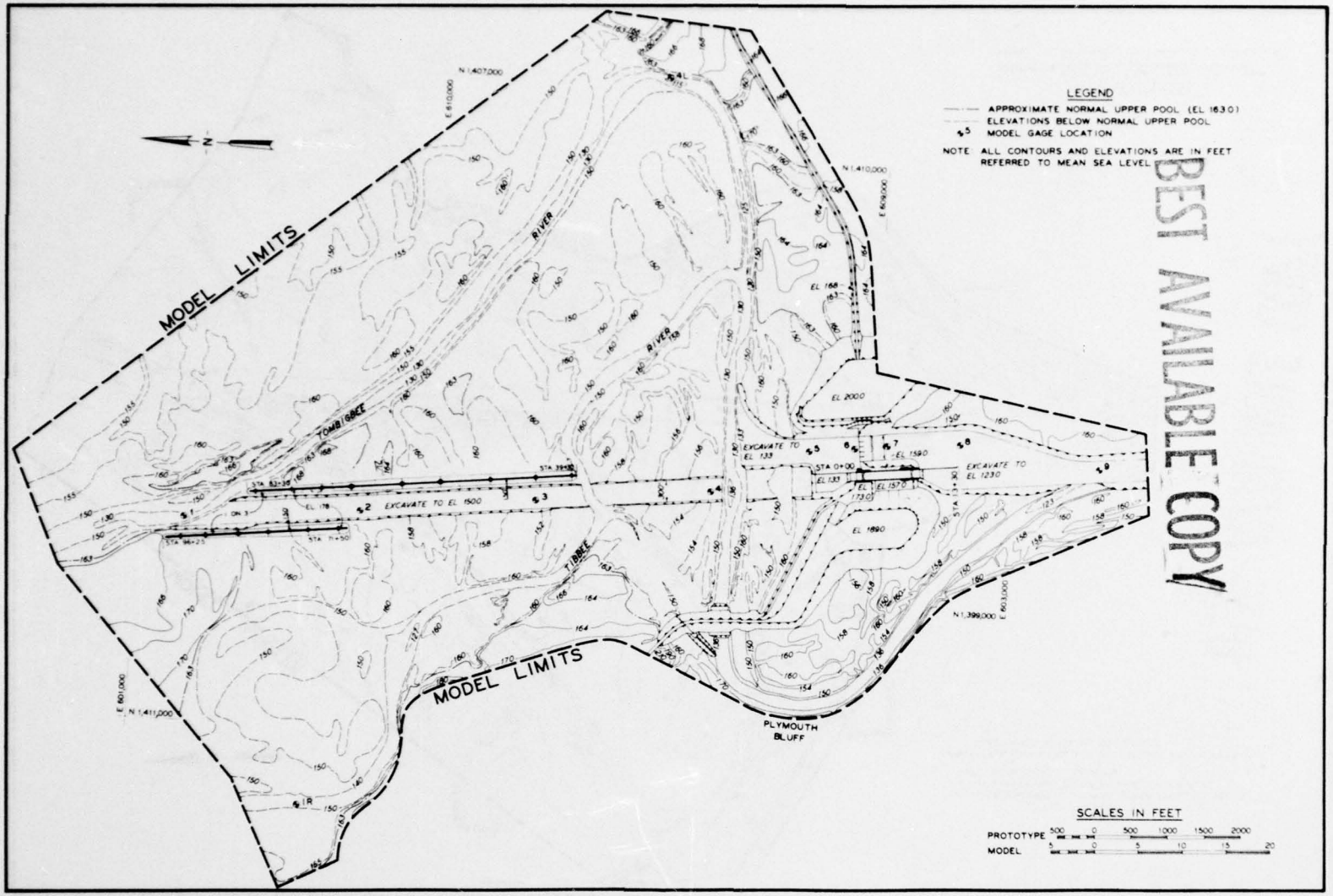

Figure 7. Plan A-1

canal near the lower end of the dike along the left bank (Plate 6). With the maximum navigable flow (180,000 cfs), currents moved from the right overbank near the lower end of the right bank dike and upstream along the canal and into the river channel.

29. Navigation conditions for downbound tows attempting to enter the canal would be extremely difficult and hazardous, particularly during the higher flows. Navigation conditions would also be difficult for tows moving through the canal because of the strong tendency for tows to be moved toward and against the left bank even during the lower flows.

Plan B

Description

30. Plan B was the same as the original design except that an earth-fill dike with a top elevation of 178.0 was located along the right bank of the canal. The dike extended from the right bank of the Tombigbee River near the upper end of the canal downstream to the left bank of the Tibbee River (Figure 8).

Results

31. Water-surface elevations shown in Table 4 indicate only local changes from those obtained with the original design. There was a small decrease in water level upstream of the entrance to the canal (gages 1 and 2) and a small increase along the right overbank (gage 1R). The differences are attributed mostly to the reduction of flow from the Tibbee River toward and into the upper reach of the lock approach canal.

32. Results shown in Plates 7-9 indicate considerable improvement in the alignment of currents near the entrance to the approach canal and within the upper reach of the canal with some increase in velocities. Currents within the canal along the reach downstream to the junction with the Tibbee River channel were generally straight and parallel to the banks of the canal. Flow from the canal and most of the flow from the right overbank moved to the left of the end of the upper guard wall, producing crosscurrents in the approach to the lock.

33. Navigation conditions near the entrance to the canal and

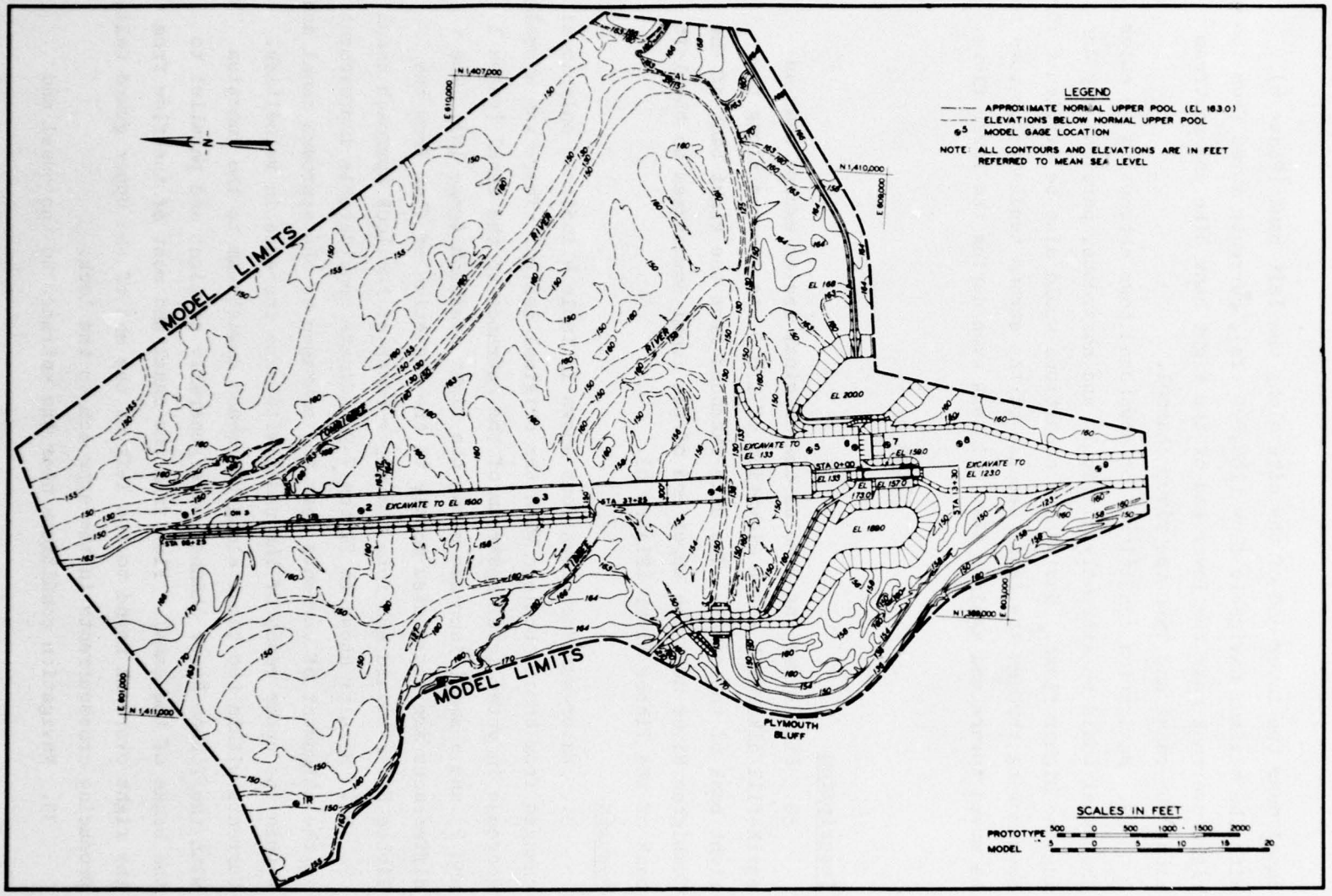

Figure 8. Plan B

within the reach upstream of the Tibbee River were considerably better than those with the original design or with the modifications of plans A and A-1. No difficulties were indicated for upbound or downbound tows in the upper reach of the canal or near the canal entrance. However, currents moving to the left and across the approach to the lock upper guard wall would produce a strong tendency for tows to be moved to the left out of the approach channel. Because of this tendency, downbound tows would experience considerable difficulty in making a satisfactory approach to the lock and would be in danger of hitting the end of the lock upper guard wall or of being moved toward the gated spillway, particularly during open river flows.

Plans C and C-Modified

Description

34. Plan C involved the modification of the landfill on the right overbank adjacent to the lock to provide a beach for recreation and to reduce the amount of erosion protection. This plan was the same as plan B except for modification of the landfill to form a straight line from the lock upstream to the access road as shown in Figure 9 and filling of the Tombigbee River channel to the right of the lock approach canal to el 145. The slope of the modified fill was 1V on 15H to provide for the recreational beach.

35. Plan C-modified was the same as plan C except for modifications designed to reduce crosscurrents in the approach to the lock and thereby improve navigation conditions for downbound tows approaching the lock. This plan (Figure 10) involved the construction of earth dikes along the left and right banks of the canal downstream of the Tibbee River channel, angling the lower 50 ft of the dike along the right bank upstream of the Tibbee River channel about 45 deg to the right, and filling the Tibbee River channel just upstream of the lock approach canal to el 150.0. The elevation of the earth dikes along the canal was at 178.0.

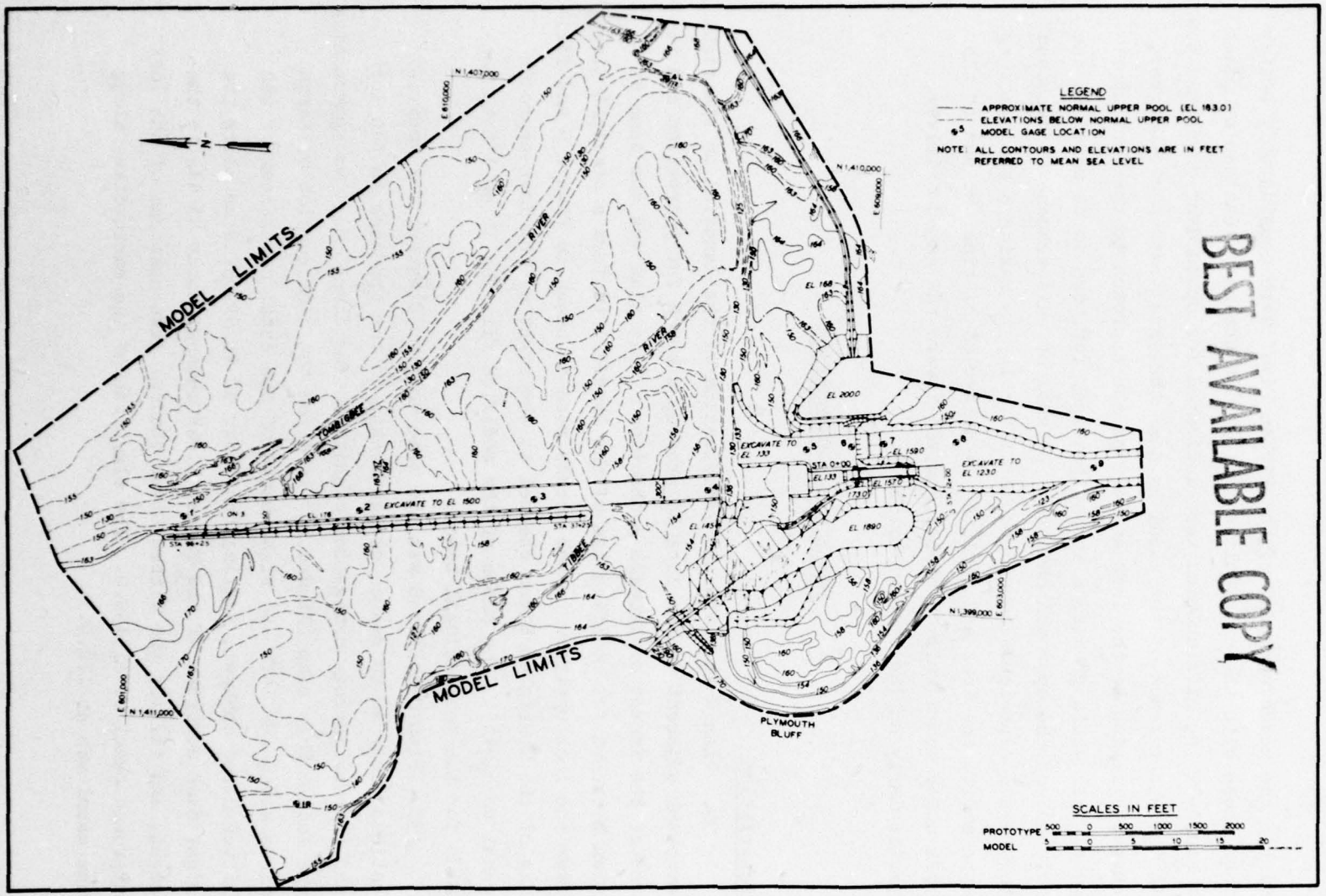

Figure 9. Plan C

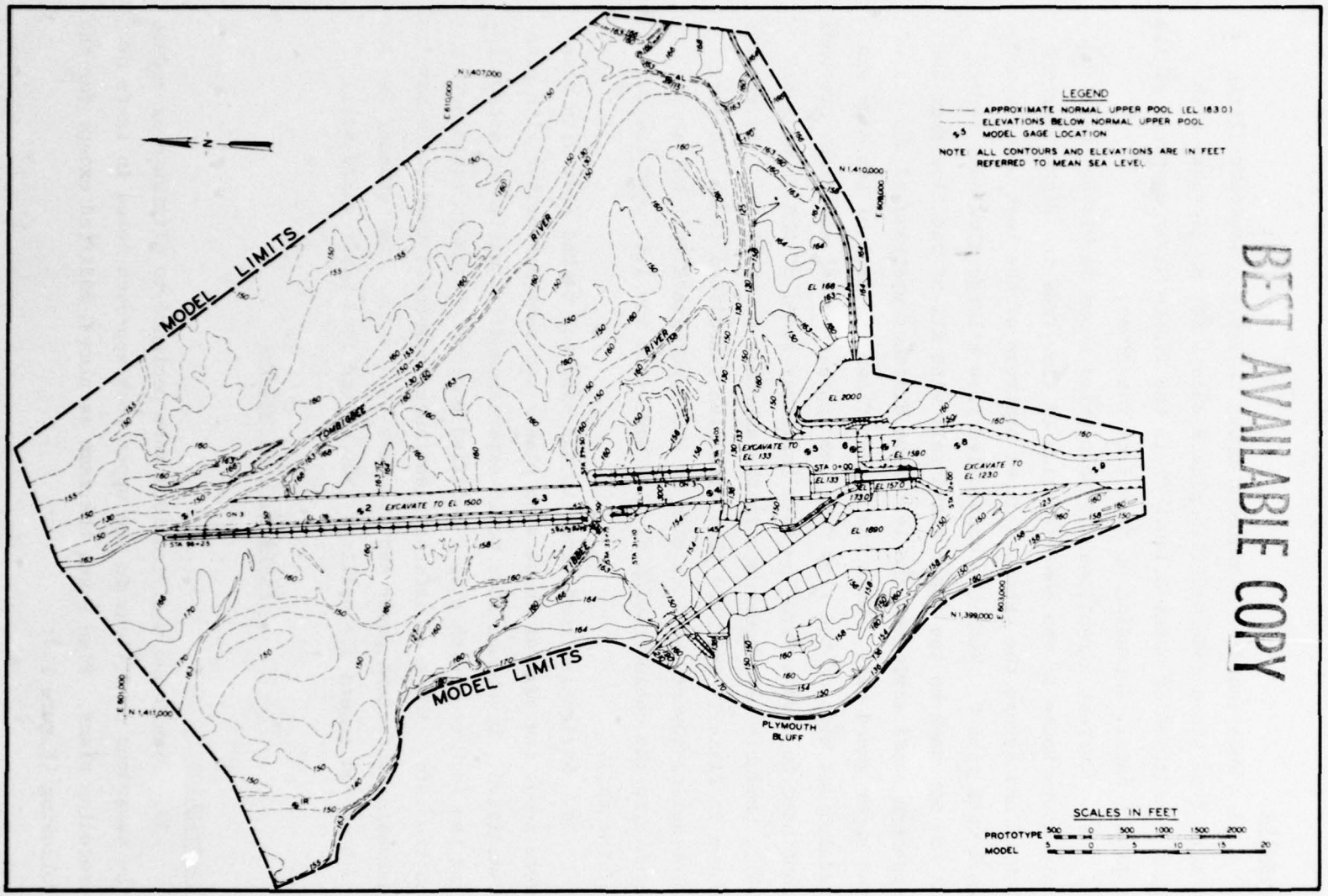

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Figure 10. Plan C-modified

Results

36. Water-surface elevations shown in Table 5 indicate little change from those obtained with plan B except for an increase with plan C-modified of about 0.1-0.2 ft in the Tibbee River upstream of the approach canal, depending on flow from the river.

37. Current directions and velocities shown in Plates 10-13 indicate an increase in the concentration of flow from the right overbank toward and across the approach canal upstream of the lock upper guard wall with plan C. With the controlled flow a large slow eddy formed in the approach to the upper guard wall with all of the flow from the approach canal moving to the left some distance upstream of the end of the upper guard wall. With the higher flows the size of the eddy was reduced but most of the flow from the approach canal and right overbank continued to move toward the left (spillway side) of the upper guard wall, producing crosscurrents in the approach to the lock. The results shown in Plate 14 indicate that with plan C-modified there was more flow moving toward the lock side of the upper guard wall but an increase in the concentration of flow moving to the left near the end of the wall.

38. Navigation conditions in the approach to the lock with plan C were about the same as those with plan B and somewhat better with plan C-modified. Downbound tows would experience difficulties in approaching the lock even with plan C-modified because of the currents moving to the left. For a satisfactory entrance, downbound tows would have to maintain sufficient power and steerage to overcome the tendency for tows to be moved toward the spillway side of the lock upper guard wall.

Plans D, D-1, and D-2

Description

39. Plan D and modifications were designed to eliminate or reduce the hazardous conditions in the upper lock approach noted in tests of preceding plans. Plan D was the same as plan C-modified except for the following (Figure 11):

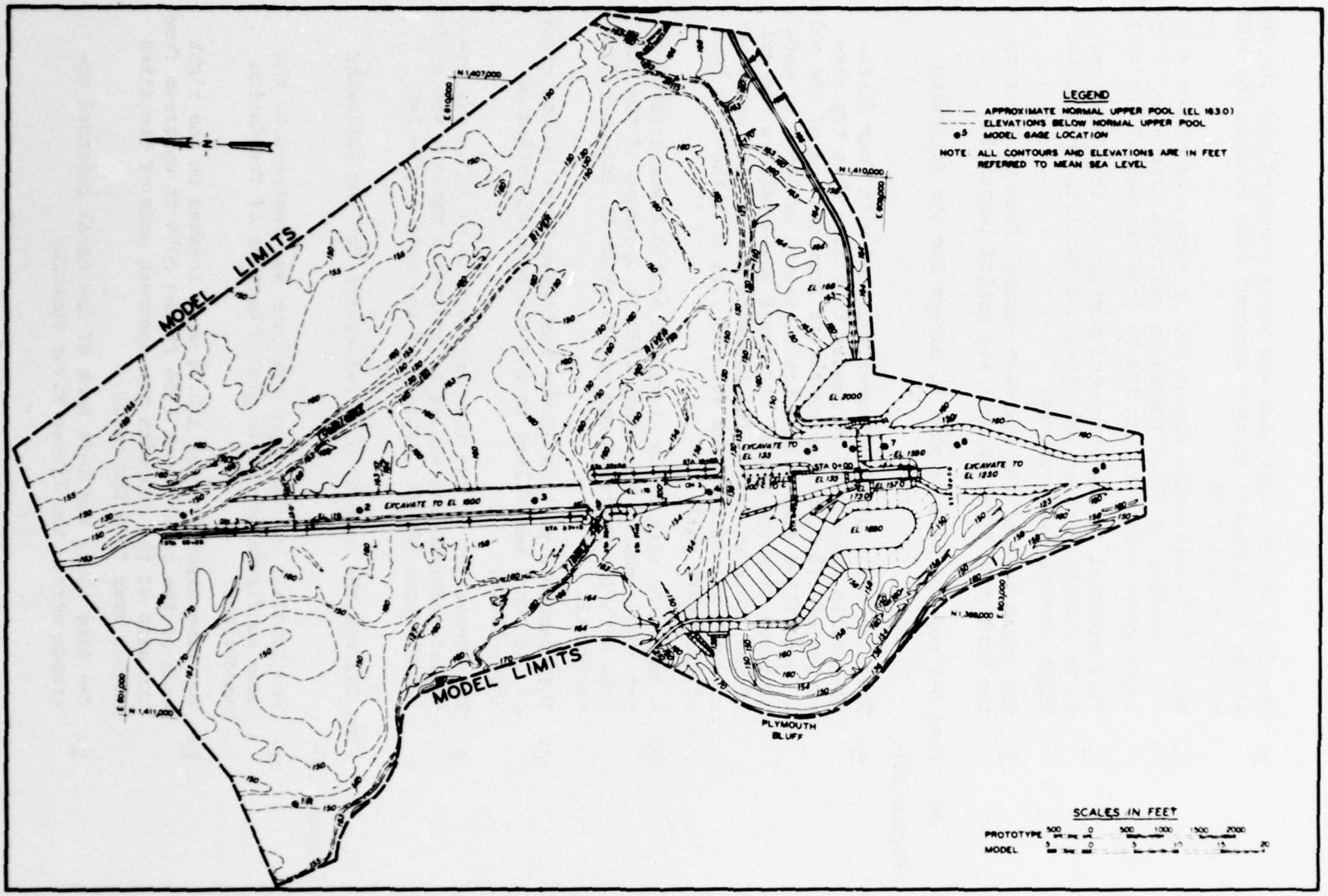


Figure 11. Plan D

a. The fill on the right bank was moved landward with the toe of the slope placed along a straight line between the lock and the access road.

b. Nine 25-ft-diam cells spaced 100 ft center to center with top elevation of 178.0 formed an upstream extension of the upper guard wall starting 100 ft from the end of the wall.

c. Fill material in the abandoned portion of the Tombigbee River channel between the canal and the fill area on the right overbank was removed.

d. The right bank of the approach channel from the lock to the Tombigbee River channel was angled landward.

40. Plan D-1 was the same as plan D, except for the following (Figure 12):

a. The nine cells of plan D were replaced with four 25-ft-diam cells spaced 245 ft center to center with top elevation of 178.0, beginning 144 ft from the end of the wall. A rock-filled dike with a top elevation of 165.0 extended upstream from the end of the upper guard wall to the end of the upstream cell. The landward side of the cells and landward toe of the dike were in line with the lock face of the guard wall.

b. A vane dike with a top elevation of 178.0 was located on the right bank of the canal 1220 ft upstream of the dam axis with the upstream end angled about 27 deg away from the canal.

c. The abandoned portion of the Tombigbee River to the right of the canal was filled to its top bank elevation of about 152.0.

d. The excavation in the lock approach to el 133.0 was extended upstream and angled to provide a maximum width of 300 ft about 900 ft upstream of the axis of the dam.

41. Plan D-2 was the same as plan D-1 except for the following (Figure 13):

a. The landfill on the right overbank was restored to the same configuration as in plan C because of foundation conditions.

b. Two vane dikes (top el 178.0) were located on the right bank of the canal about 1386 ft and 2054 ft upstream from the axis of the dam with the upstream ends of the dikes angled away from the canal.

c. The dike along the left bank of the canal extended upstream across the Tibbee River channel.

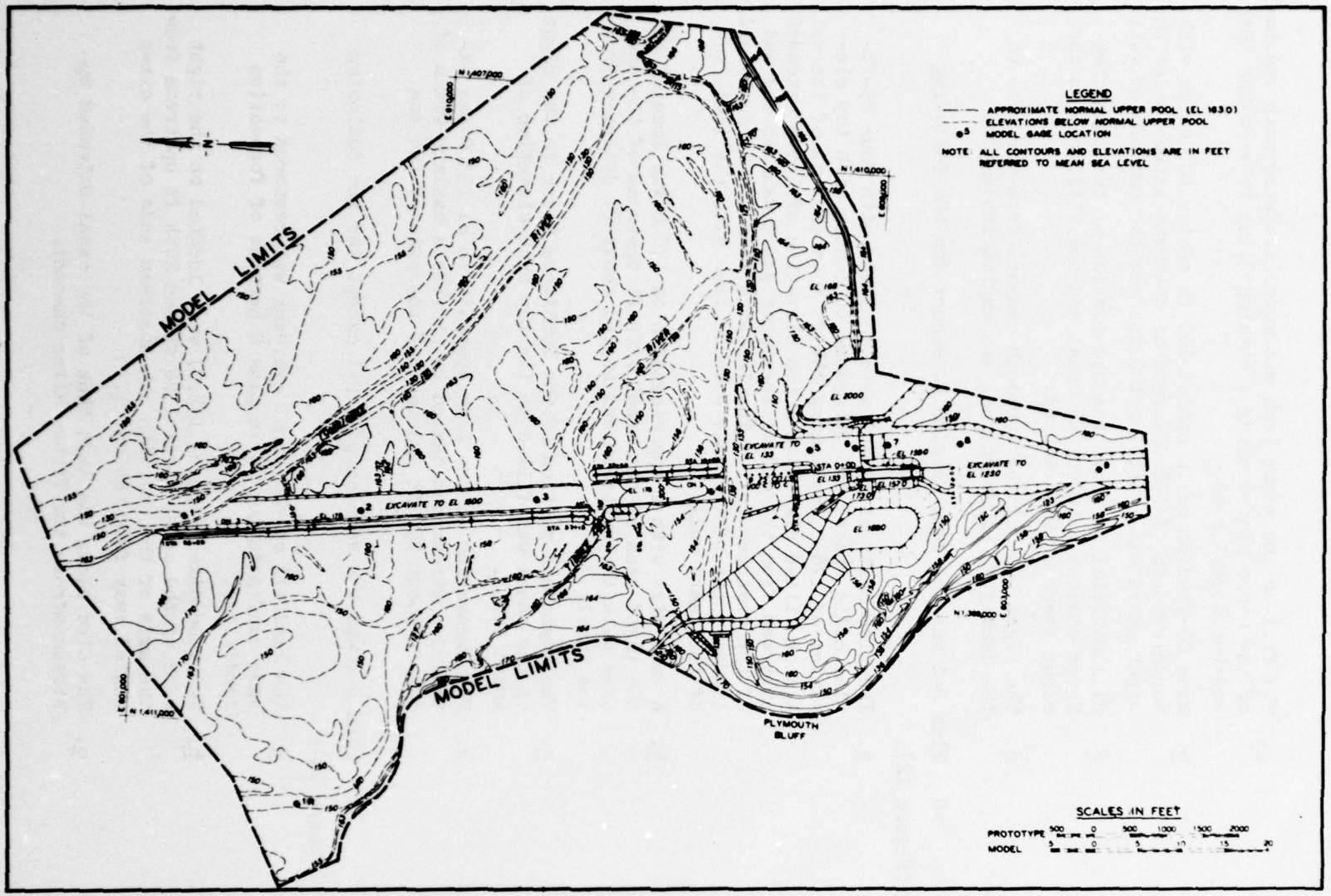


Figure 11. Plan D

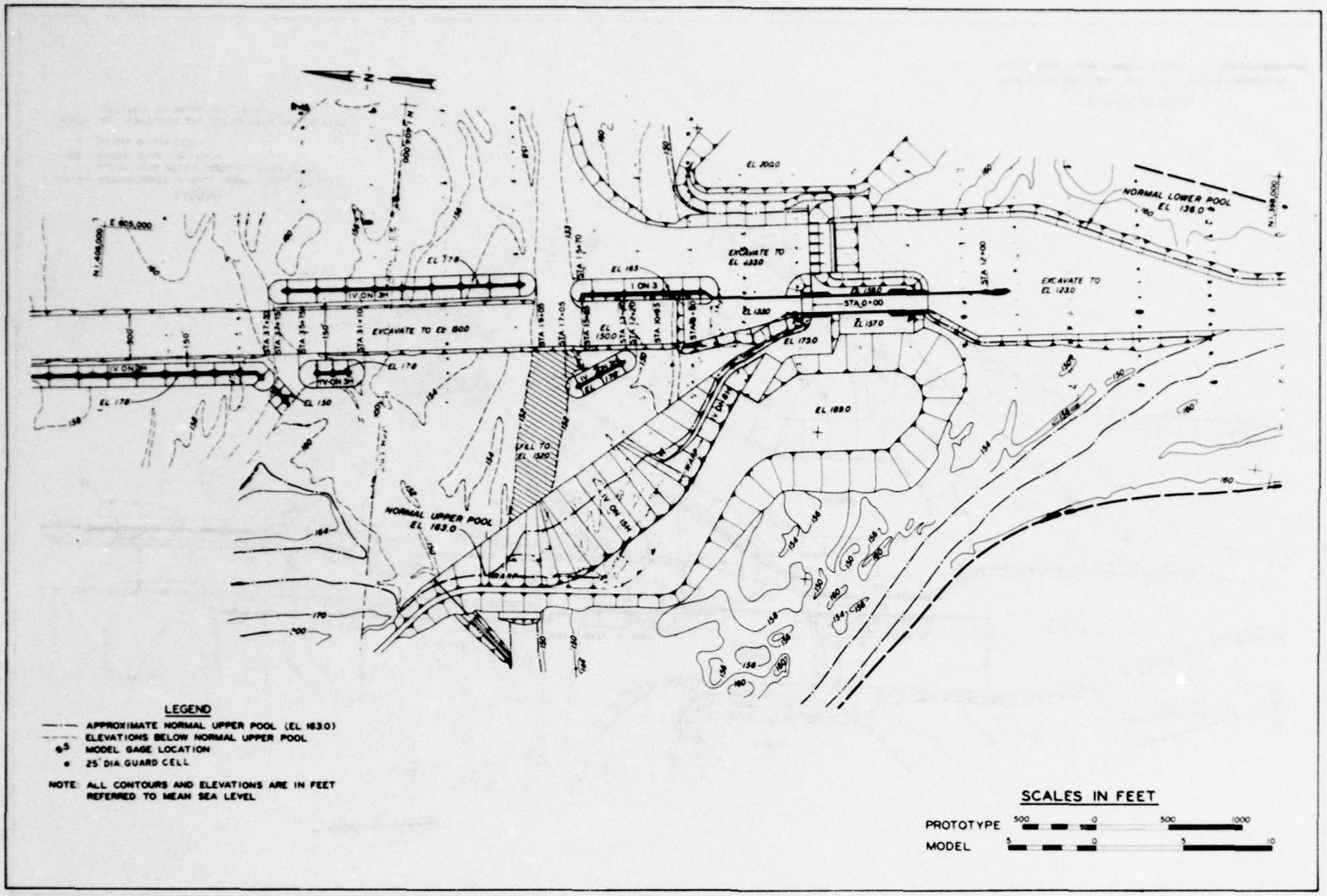


Figure 12. Plan D-1

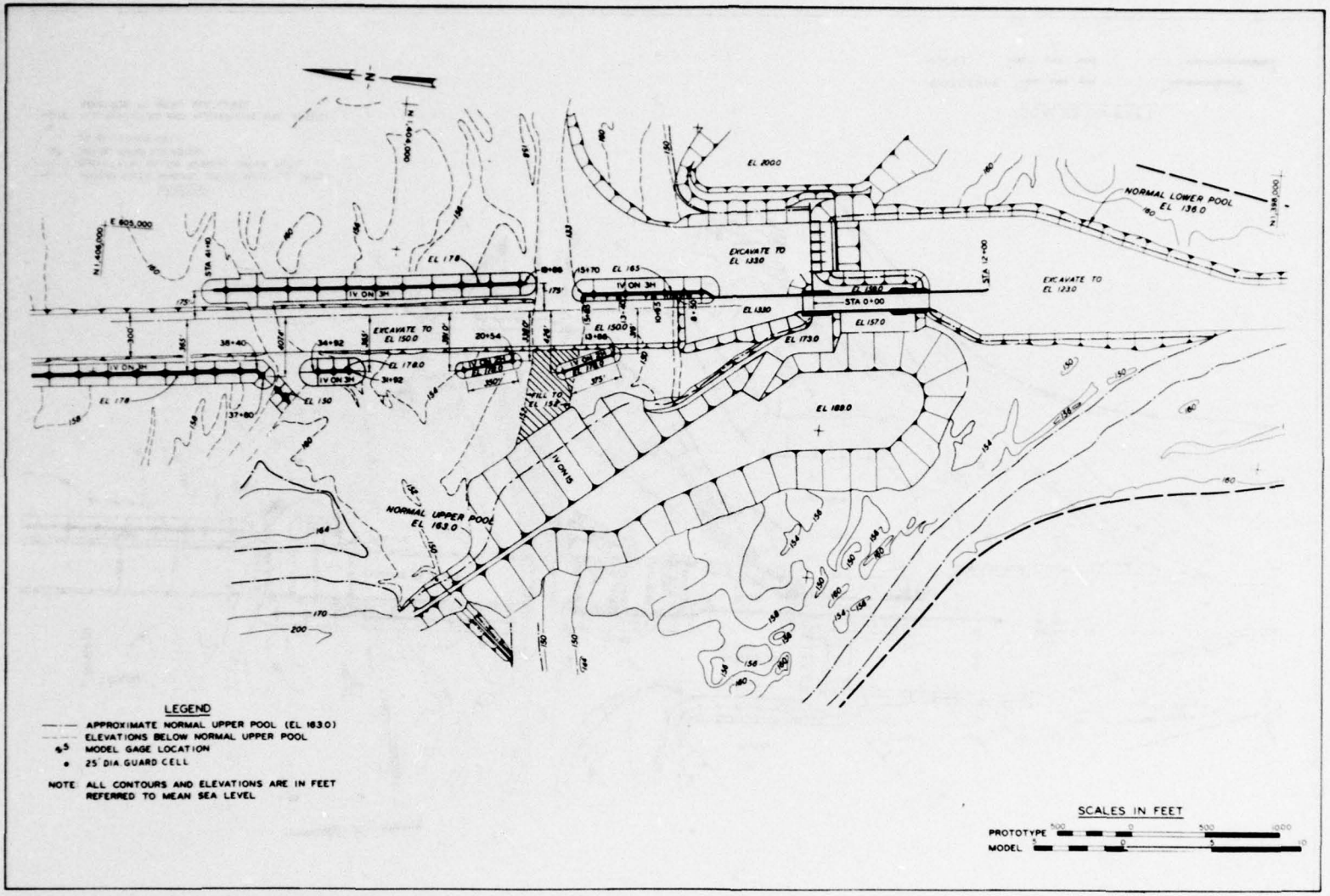


Figure 13. Plan D-2

d. Fillet was placed between the lock and the gated section of the dam just upstream of the fixed weir to about el 170.0 to provide a guide for flow from along the lock wall into the gate bay nearest the lock.

Results

42. Water-surface elevations with plan D were about 0.2-0.3 ft higher in Tibbee River area (gage 1R) and about 0.1-0.2 ft lower in the upper reaches of the approach canal (gages 1 and 2) than those obtained with the original plan (Table 6). Water-surface elevations with plan D-1 were about the same as those with plan D except for increases of 0.2 and 0.1 ft upstream of the dam with the 115,000 and 180,000 cfs, respectively. The differences in water level across the spillway (gages 6 and 7) were about the same as those with the original design and somewhat lower between gages 5 and 8.

43. Water-surface elevations with plan D-2 (Table 7) indicate little difference from those obtained with the original design with the controlled river flow. With the 57,000-cfs flow, water-surface elevations were either lower or about the same as those obtained with the original design except in the Tibbee River area (gage 1R), where water levels were about 0.3 ft higher. With the 115,000- and 180,000-cfs flows, stages were 0.2 and 0.1 ft higher, respectively, except in the Tibbee River area, where water levels were about 0.5 and 0.3 ft higher, respectively. With a flow of 57,000 cfs out of the Tibbee River and no flow from the Tombigbee River, results indicated stages from 0.2 to 0.4 ft lower in the reach near the upper entrance to the canal and about 2.7 ft higher in the Tibbee River area (gage 1R) than those obtained with normal division of flow between the two streams.

44. The distribution of flow through the gated spillway shown in Table 8 indicates a considerable improvement in the flow through the gate bay nearest the lock with the fillet between the right spillway abutment and the lock included in plan D-2.

45. Current directions and velocities obtained with plan D indicate considerable flow from right to left across the approach to the lock (Plate 15). Velocities in the crosscurrents varied from about 2.5 to 2.8 fps with the flows tested. Navigation conditions with this

plan would be affected by the crosscurrents and currents from the Tibbee River channel. Downbound tows could enter the approach canal from the Tombigbee River channel but would encounter some difficulty in passing the Tibbee River channel and in the approach to the lock upper guard wall. Currents in the approach canal near the Tibbee River channel would tend to move tows toward the left bank, and crosscurrents upstream of the upper guard wall would tend to move tows toward and against the cells forming the extension to the guard wall.

46. Current directions and velocities obtained with plan D-1 (Plates 16-18) indicate an increase in the flow moving through the ports in the upper guard wall. The crosscurrents were considerably less than those with plan D and flows of 57,000 and 115,000 cfs. Most of the crosscurrents with the higher flows were concentrated upstream of the end of the line of cells and dike. Currents near the mouth of the Tibbee River moved toward the left bank of the approach canal. With the 180,000-cfs flow, there was some flow moving directly across the canal. Navigation conditions with this plan were better than those with plan D, and a satisfactory approach to the lock could be made by downbound tows provided the effects of the currents near the mouth of Tibbee River and upstream of the end of the upper guard wall are considered. Near the mouth of the Tibbee River currents would tend to move tows toward the left bank of the canal unless sufficient power and steerage are maintained to overcome the effects of the currents. Downbound tows would have to approach the lock from along the right side of the approach canal during the higher flows to prevent their being moved toward the rock dike and cells forming an extension of the upper guard wall.

47. Current direction and velocities shown in Plates 19-23 indicate that with plan D-2 there was some additional increase in the flow moving through the ports in the upper guard wall and a decrease in the crosscurrents in the approach to the lock. Velocities in the crosscurrents with the 57,000-cfs flow were less than those with plan D-1 but somewhat higher with the higher flows. However, even with the high flows the extent of the crosscurrents was considerably less than with

the previous plan. Currents within the approach canal to the lock were generally straight with essentially no crosscurrents with the 30,000-cfs flow. With the higher flows the currents were affected by flow from the right overbank and the Tibbee River but the intensity of any cross-currents was generally low (Photos 3 and 4). Eddies of low intensity formed in the canal upstream and downstream of the mouth of the Tibbee River during the higher flows.

48. Current directions and velocities obtained with an assumed flood on the Tibbee River (57,000 cfs) and no flow in the Tombigbee River (Plate 23 and Photo 5) indicate considerable variations in flow conditions within the approach canal with strong crosscurrents near the mouth of the Tibbee River. Flow in the approach canal upstream of the mouth of the Tibbee River was in an upstream direction while flow in the canal adjacent to the mouth of the Tibbee River moved directly across the canal with velocities of 5.4-8.2 fps. Currents in the approach canal below the mouth of the Tibbee River were affected by an eddy just downstream and flow from the right overbank moving diagonally across the canal with velocities of more than 6-7 fps.

49. Navigation conditions with plan D-2 were considerably better than those with any of the preceding plans, and no serious difficulties were indicated with the normal distribution of flow between the Tombigbee and Tibbee Rivers. Flow from the Tibbee River would tend to move tows toward the left side of the lock approach canal but the effect of the currents was generally small and could be easily overcome with some rudder control (Photos 6-9). Two-way traffic could be maintained in the approach canal during most flows but caution would be required during the higher flows. With high flows in the Tibbee River and no flow in the Tombigbee River, navigation through the lower reach of the approach canal could be difficult and hazardous and two-way traffic from the Tibbee River to the lock would not be advisable under those conditions (Photo 10).

Plan E

Description

50. Plan E was developed to provide for navigation into and from the Tibbee River from the lock approach canal without affecting navigation within the canal. The design was based on the movement of tows in the Tibbee River having dimensions no greater than 480 ft long and 70 ft wide with a draft of 8 ft. The plan was the same as plan D-2 except for the following modifications (Figure 14):

a. A canal 440 ft wide was excavated normal to the lock approach canal with flared approaches to the canal curving toward the upstream and downstream as shown in Figure 14. The approaches to the canal had a bottom width of 220 ft at el 150.

b. A U-shaped dike was located on the overbank between the two approach canals and short dikes extended along the left and right banks of the canal with tops at el 178.

c. Portions of the earth dike along the right bank of the lock approach canal were removed to provide for the approaches to and from the Tibbee River canal.

Results

51. Water-surface elevations shown in Table 9 indicate little difference between plan E and plan D-2 except for a lowering of about 0.5 ft on the Tibbee River (gage 1R) with the 57,000-cfs flow. Stages were about 0.1 and 0.2 ft lower in the lock approach canal and 0.3 and 0.4 ft lower in the Tibbee River channel with flows of 115,000 and 180,000 cfs, respectively. With the flood on the Tibbee River (57,000 cfs) and no flow in the Tombigbee River, stages were about 2.0 ft lower in the Tibbee River with plan E than with plan D-2 and about 0.1-0.5 ft higher in the lock approach canal with the greatest difference occurring near the upstream end of canal. The drop in water level across the gated spillway was about the same as or slightly lower than that with plan D-2.

52. Current directions and velocities shown in Plates 24-27 indicate a decrease in the concentration of flow moving across the lock approach canal from the right overbank compared with plan D-2. Currents

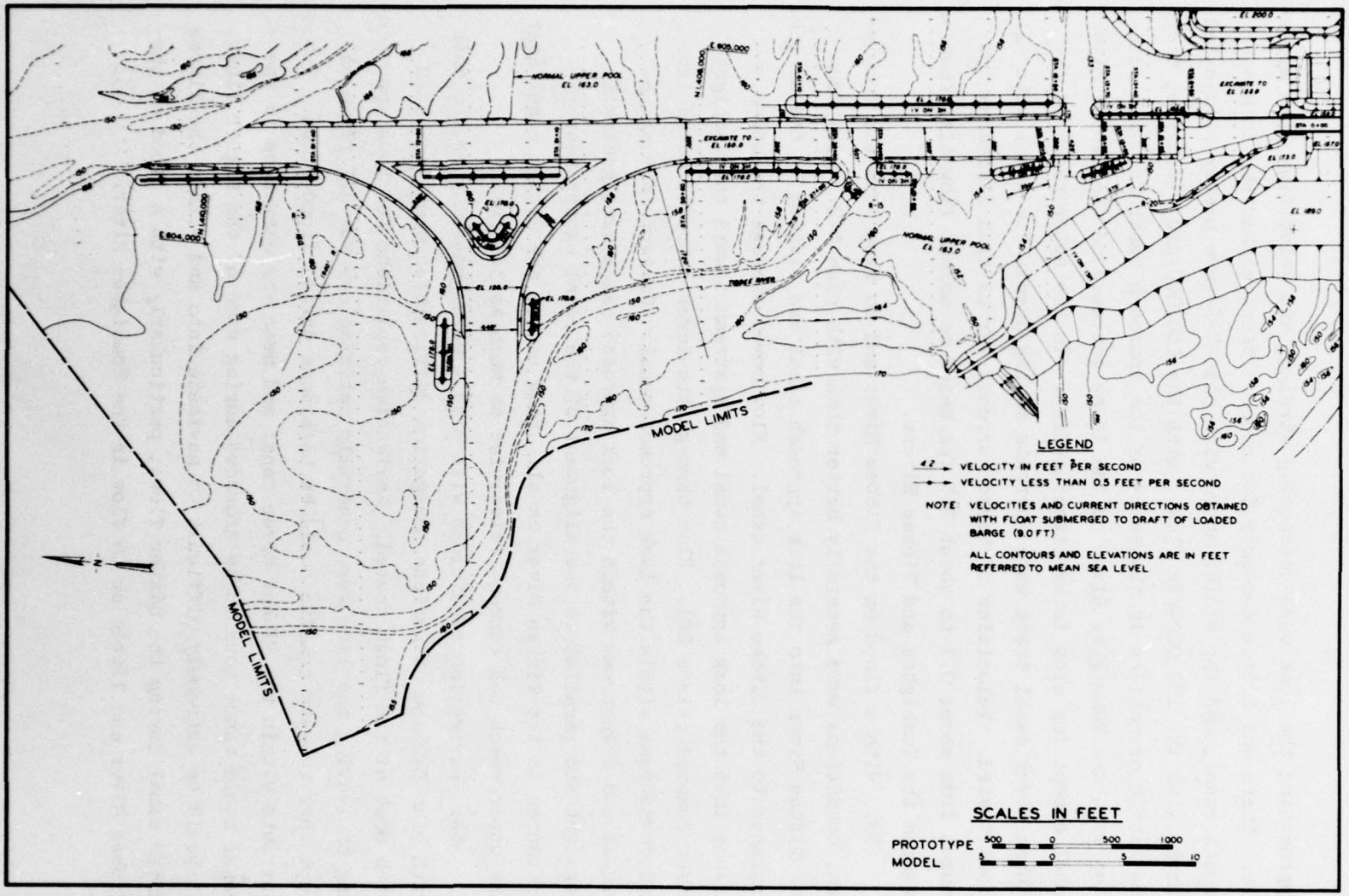


Figure 14. Plan E

approaching the lock were reasonably straight and velocities were moderate. There was little tendency for crosscurrents within the lock approach canal, and the eddies noted with plan D-2 were mostly eliminated except with the 180,000-cfs flow. With the 180,000-cfs discharge, there was little or no flow in the reach of the approach canal from its junction with the Tombigbee River to the lower entrance to the Tibbee River canal except for slow intermittent eddies. In the upper reach of the Tibbee River canal there were currents moving across the canal with all flows tested. Velocities of these currents varied with discharge and ranged from about 0.7 to about 2.5 fps based on normal flow distribution between the Tombigbee and Tibbee Rivers.

53. With a flood on the Tibbee River and no flow from the Tombigbee, conditions were generally better than with plan D-2. Flow from the Tibbee River into the lock approach canal was divided by the divided entrance to the Tibbee River canal. Flow moved through the upper entrance into the lock approach canal and upstream toward the Tombigbee River channel (Plate 28). Flow through the lower entrance moved into and downstream within the lock approach canal. Currents moving upstream and downstream within the lock approach canal were generally straight and parallel to the alignment of the canal except near the entrances to the Tibbee River canal. Flow across the Tibbee canal near the upper reach had current velocities as much as 5.7 fps.

54. Navigation conditions with plan E were generally better than with plan D-2 and no serious navigation difficulties were indicated with most of the flows tested. Navigation conditions for tows approaching or leaving the lock were generally satisfactory for all flows except that two-way traffic could be hazardous during flood flows. Crosscurrents within the Tibbee River canal and near the entrances to the canal could cause tows to be grounded during some of the higher flows. It would be extremely difficult to navigate into and within the Tibbee River canal during the higher flows, particularly with a flood on the Tibbee River and little or no flow in the Tombigbee River.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Limitation of Model Results

55. The analysis of the results of this investigation is based principally on a study of (a) the effects of various plans and modifications on water-surface elevations, current directions, and velocities, and (b) the effects of resulting currents on the behavior of the model towboat and tow. In evaluating test results, consideration should be given to the fact that small changes in direction of flow or in velocities are not necessarily changes produced by a modification in plan since several floats introduced at the same point may follow a different path and move at slightly different velocities because of pulsating currents and eddies. Current directions and velocities shown in the plates were obtained with floats submerged to a depth of a loaded barge (9 ft prototype) and are indicative of the currents that would affect the behavior of tows.

56. The small scale of the model made it difficult to reproduce accurately the hydraulic characteristics of the prototype structures or to measure water-surface elevations within an accuracy greater than ±0.1 ft prototype. Also, the model limits did not include all of the floodway areas covered by the higher flows and included only about half of the overflow dike along the left overbank. The model was of the fixed-bed type and was not designed to simulate the movement of sediment in the prototype; therefore, changes in channel configurations and slopes resulting from changes in the channel bed and banks that might be caused by the structure or changes in flow conditions could not be developed naturally.

Summary of Results and Conclusions

57. The following results and conclusions were developed during this investigation:

a. No serious navigation difficulties were indicated for

tows entering or leaving the lower lock approach with any of the plans tested.

b. Navigation upstream of the lock would be affected by crosscurrents produced by flow over the right overbank and from the Tibbee River.

c. With the original plan downbound tows would experience considerable difficulties entering the lock approach canal, maintaining satisfactory alignment within the canal, and overcoming the crosscurrents near the end of the lock upper guard wall during most flows.

d. Most of the navigation difficulties within the lock approach canal and in the lock approach could be eliminated with the modifications developed in plan D-2 or plan E. Even with these plans, two-way traffic could be hazardous with the higher flows approaching 180,000 cfs and with a flood on the Tibbee River and little or no flow in the Tombigbee River.

e. Satisfactory navigation conditions from the lock approach canal into the Tibbee River could be provided for limited size tows during most flows with the proposed canal and entrances as developed in plan E. With the higher flows, there would be a strong tendency for tows in the canal to be moved out of the canal and grounded.

f. Distribution of flow through the gated spillway was reasonably uniform except through the gate bay nearest the lock. Flow through the gate nearest the lock could be increased with a fillet between the spillway right abutment and the lock as in plans D-2 and E.

g. The modifications of plans D-2 and E would produce some increase in water-surface elevations in the Tombigbee River at the upper end of the lock approach canal of from 0.1 to 0.2 ft compared with the original plan. Similarly, stages in the lower reach of the Tibbee River would be increased from 0.3 to 0.5 ft.

h. With a flood on the Tibbee River of 57,000 cfs and no flow in the Tombigbee River, stages in the lower Tibbee River could be as much as 2.7 ft higher than with the same flow distributed normally between the two rivers.

i. The drop in water level across the gated spillway (gages 6 and 7) varied from about 0.2 to 0.5 ft, decreasing with increase in discharge, and was not affected appreciably by the plan modifications. The maximum drop in the water level from the end of the upper guard wall to the end of the lower guard wall (gages 5-8) was on the order of 0.7-0.9 ft with flows of 57,000 and 115,000 cfs and less with the 180,000-cfs flow.

Table 1

Water-Surface Elevations with Original Design

Gages	Water-Surface Elevation (ft) at Indicated Discharge			
	30,000 cfs	57,000 cfs	115,000 cfs	180,000 cfs
1	163.3	163.7	169.8	172.3
1R	163.3	163.7	169.7	172.3
2	163.3	163.7	169.7	172.2
3	163.2	163.5	169.7	172.2
4	163.1	163.2	169.6	172.1
4L	163.2	163.5	169.6	172.1
5	163.0	163.0	169.4	172.0
6	163.0*	162.6	169.0	171.8
7	150.6*	162.1*	168.6*	171.6*
8	150.8	162.1	168.6	171.6
9	150.6	162.1	168.7	171.6

* Controlled elevations based on normal pool and computed tailwater furnished.

Table 2

Flow Distribution Through Gated Spillway with Original Design

Gate Bay No.*	Percent Flow Distribution Through Gated Spillway at Indicated River Discharge		
	57,000 cfs	115,000 cfs**	180,000 cfs**
1	14.8	15.0	14.7
2	20.1	20.4	20.8
3	21.6	21.9	21.9
4	21.9	22.0	21.6
5	21.6	20.7	21.0

* Gate bays numbered from right to left.

** Includes flow over the overflow dike on the left bank.

Table 3

Water-Surface Elevations with Plans A and A-1

Gages	Water-Surface Elevation (ft) at Indicated Discharge				
	Plan A			Plan A-1	
	57,000 cfs	115,000 cfs	180,000 cfs	115,000 cfs	180,000 cfs
1	163.6	169.8	172.2	169.8	172.2
1R	163.7	169.9	172.4	169.9	172.4
2	163.6	169.8	172.2	169.7	172.2
3	163.4	169.7	172.2	169.7	172.2
4	163.1	169.6	172.1	169.6	172.1
4L	163.4	169.7	172.2	169.7	172.1
5	163.0	169.4	172.0	169.4	172.0
6	162.5	169.0	171.8	169.0	171.8
7	162.1	168.6	171.6	168.6	171.6
8	162.1	168.6	171.6	168.6	171.6
9	162.1*	168.7*	171.6*	168.7*	171.6*

* Controlled elevations.

Table 4

Water-Surface Elevations with Plan B

Gages	Water-Surface Elevation (ft) at Indicated Discharge		
	57,000 cfs	115,000 cfs	180,000 cfs
1	163.5	169.8	172.1
1R	163.9	169.9	172.5
2	163.5	169.8	172.1
3	163.4	169.7	172.1
4	163.2	169.7	172.1
4L	163.4	169.7	172.1
5	163.0	169.5	172.0
6	162.6	169.0	171.8
7	162.0	168.6	171.6
8	162.1	168.6	171.6
9	162.1*	168.7*	171.6*

* Controlled elevations.

Table 5

Water-Surface Elevations with Plans C and C-Modified

	Water-Surface Elevation (ft) at Indicated Discharge						
	Plan C				Plan C-Modified		
Gages	30,000 cfs	57,000 cfs	115,000 cfs	180,000 cfs	57,000 cfs	115,000 cfs	180,000 cfs
1	163.2	163.5	169.8	172.1	163.5	169.8	172.2
1R	163.3	163.9	169.9	172.5	164.0	170.1	172.6
2	163.2	163.5	169.8	172.1	163.5	169.8	172.2
3	163.2	163.4	169.7	172.1	163.4	169.7	172.2
4	163.1	163.2	169.7	172.1	163.1	169.6	172.1
4L	163.2	163.4	169.7	172.1	163.4	169.7	172.1
5	163.0	163.0	169.5	172.0	163.0	169.4	172.0
6	163.0*	162.6	169.0	171.8	162.6	169.0	171.8
7	150.6	162.0	168.6	171.6	162.0	168.6	171.6
8	150.8	162.1	168.6	171.6	162.1	168.6	171.6
9	150.6*	162.1*	168.7*	171.6*	162.1*	168.7*	171.6*

* Controlled elevations.

Table 6

Water-Surface Elevations with Plans D and D-1

Gages	Water-Surface Elevations (ft) at Indicated Discharge					
	Plan D			Plan D-1		
	57,000 cfs	115,000 cfs	180,000 cfs	57,000 cfs	115,000 cfs	180,000 cfs
1	163.5	169.8	172.1	163.5	169.9	172.2
1R	164.0	170.0	172.5	164.0	170.2	172.6
2	163.5	169.7	172.1	163.5	169.9	172.2
3	163.5	169.6	172.1	163.4	169.8	172.2
4	163.2	169.6	172.1	163.2	169.8	172.2
4L	163.5	169.7	172.2	163.4	169.8	172.2
5	162.9	169.4	172.0	162.8	169.5	172.1
6	162.6	169.0	171.8	162.6	169.2	171.9
7	162.1	168.6	171.6	162.1	168.7	171.7
8	162.1	168.7	171.7	162.1	168.7	171.7
9	162.1*	168.7*	171.6*	162.1*	168.7*	171.6*

* Controlled elevations.

Table 7

Water-Surface Elevations with Plan D-2

Gages	Water-Surface Elevations (ft) at Indicated Discharge				
	30,000 cfs	57,000 cfs	115,000 cfs	180,000 cfs	57,000 cfs**
1	163.3	163.5	169.9	172.3	163.1
1R	163.3	164.0	170.2	172.6	166.7
2	163.3	163.5	169.9	172.3	163.3
3	163.3	163.5	169.9	172.3	163.5
4	163.2	163.4	169.8	172.2	163.1
4L	163.3	163.5	169.8	172.2	163.2
5	163.1	162.9	169.4	172.0	162.9
6	163.0*	162.6	169.1	171.8	162.6
7	150.6	162.1	168.6	171.6	162.1
8	150.8	162.1	168.6	171.6	162.1
9	150.6*	162.1*	168.7*	171.6*	162.1*

* Controlled elevations.
** Total discharge through Tibbee River (no flow in Tombigbee River).

Table 8

Flow Distribution Through Gated Spillway with Plan D-2

Gate Bay No.*	Percent Flow Distribution Through Gated Spillway at Indicated River Discharge					
	No Fill Adjacent to Lock and Dam Abutment			Fill Adjacent to Lock and Dam Abutment		
	57,000 cfs	115,000 cfs**	180,000 cfs**	57,000 cfs	115,000 cfs**	180,000 cfs**
1	14.8	14.4	13.9	17.1	15.1	15.7
2	20.3	20.1	19.5	20.6	20.5	20.3
3	21.3	21.9	21.6	20.5	21.3	21.1
4	21.8	22.0	22.4	21.6	22.3	22.0
5	21.8	21.6	22.6	20.2	20.8	20.9

* Gate bays numbered from right to left.
** Includes flow over the overflow dike on the left bank.

Table 9

Water-Surface Elevations with Plan E

Gages	Water-Surface Elevations (ft) at Indicated Discharge				
	30,000 cfs	57,000 cfs	115,000 cfs	180,000 cfs	57,000 cfs**
1	163.3	163.5	169.8	172.2	163.5
1R	163.3	163.5	169.9	172.2	164.7
2	163.3	163.5	169.8	172.1	163.8
3	163.3	163.5	169.8	172.1	163.8
4	163.2	163.4	169.7	172.0	163.2
4L	163.3	163.5	169.7	172.1	163.4
5	163.1	162.8	169.3	171.9	162.8
6	163.0*	162.6	169.0	171.7	162.6
7	150.6	162.1	168.6	171.6	162.1
8	150.8	162.1	168.6	171.6	162.1
9	150.6*	162.1*	168.7*	171.6*	162.1*

* Controlled elevations.

** Total discharge through Tibbee River (no flow in Tombigbee River).

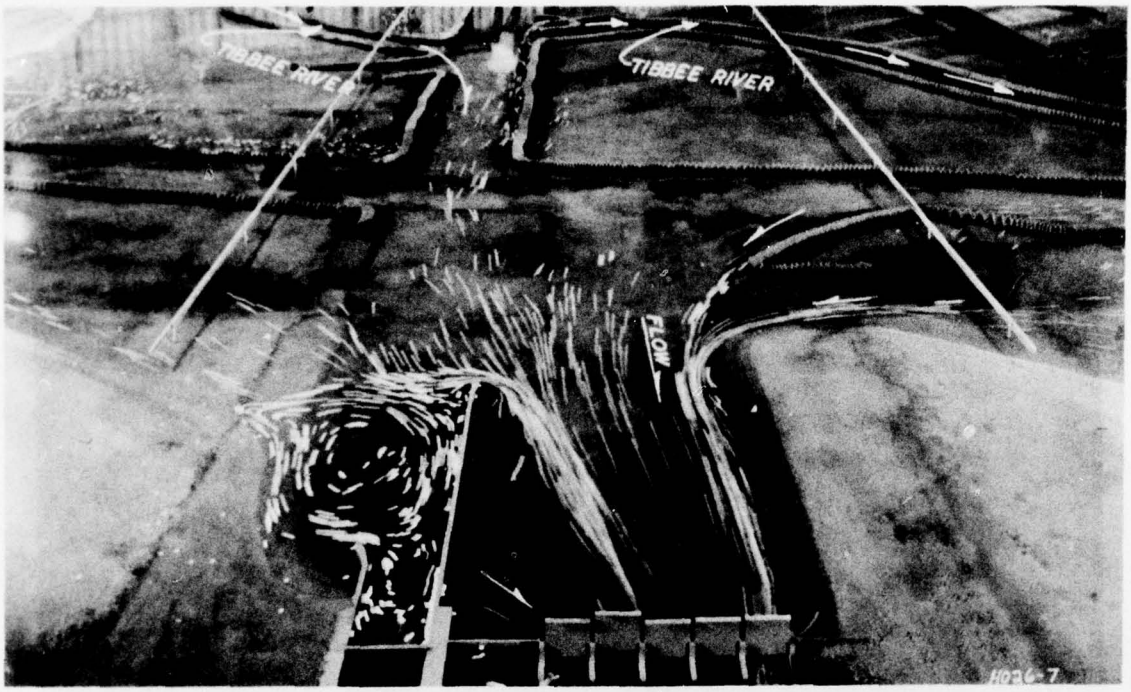


Photo 1. Original plan with discharge of 57,000 cfs and upper pool elevation of 163.0. Note surface currents in the upper lock approach and in the approach to the gated spillway

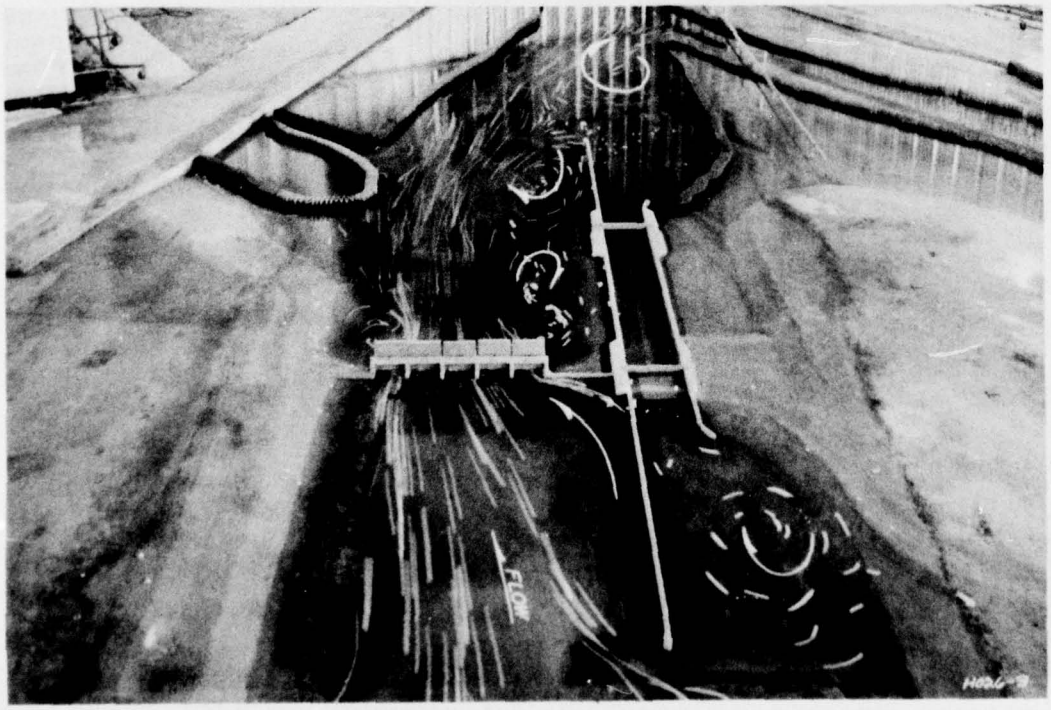


Photo 2. Original plan with discharge of 57,000 cfs and tailwater elevation of 162.1. Note surface currents through the gated spillway and in the lower lock approach

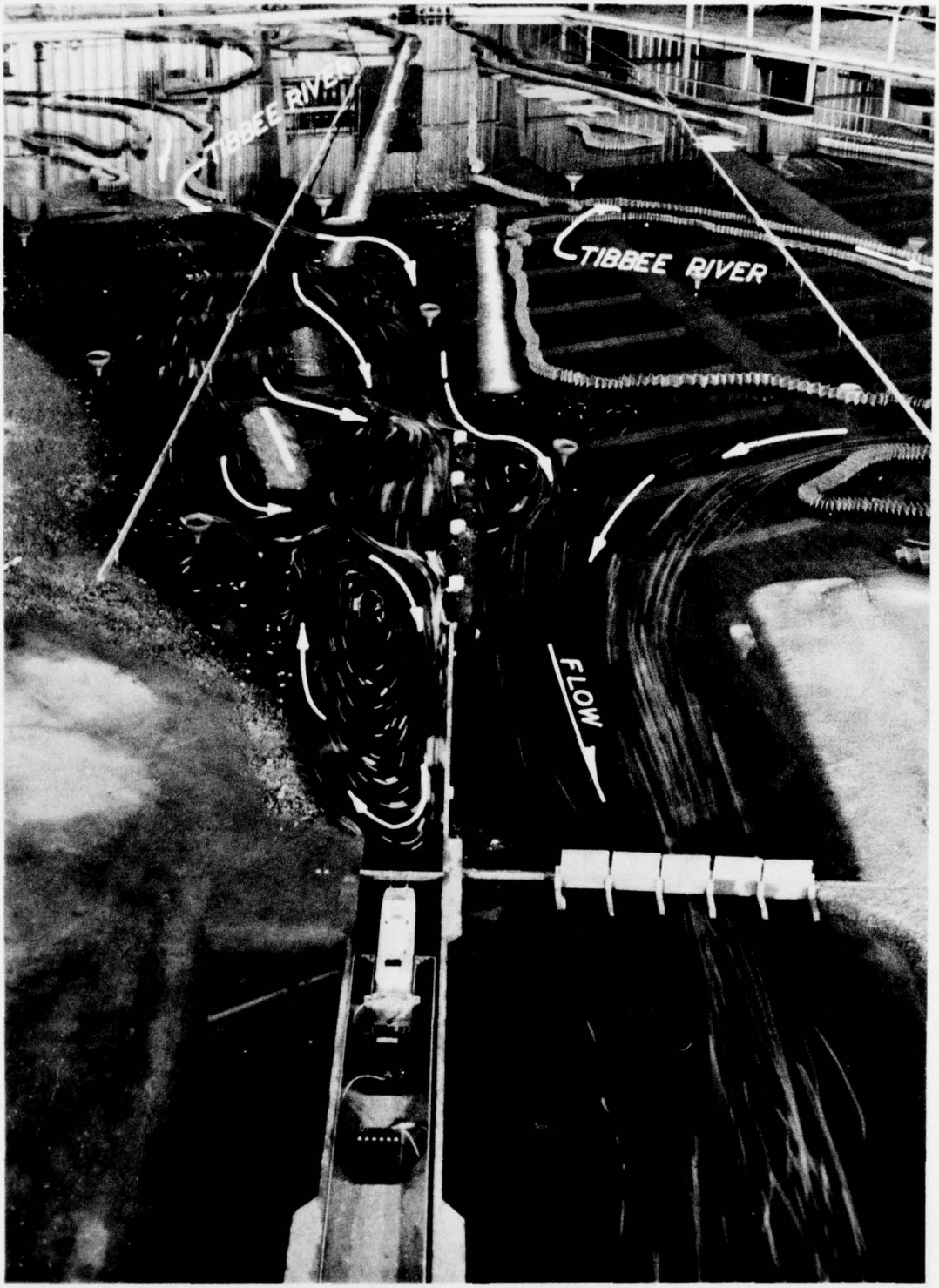


Photo 3. Plan D-2 with discharge of 57,000 cfs and upper pool elevation of 162.9. Note alignment of surface currents from right overbank and Tibbee River toward the lock approach canal

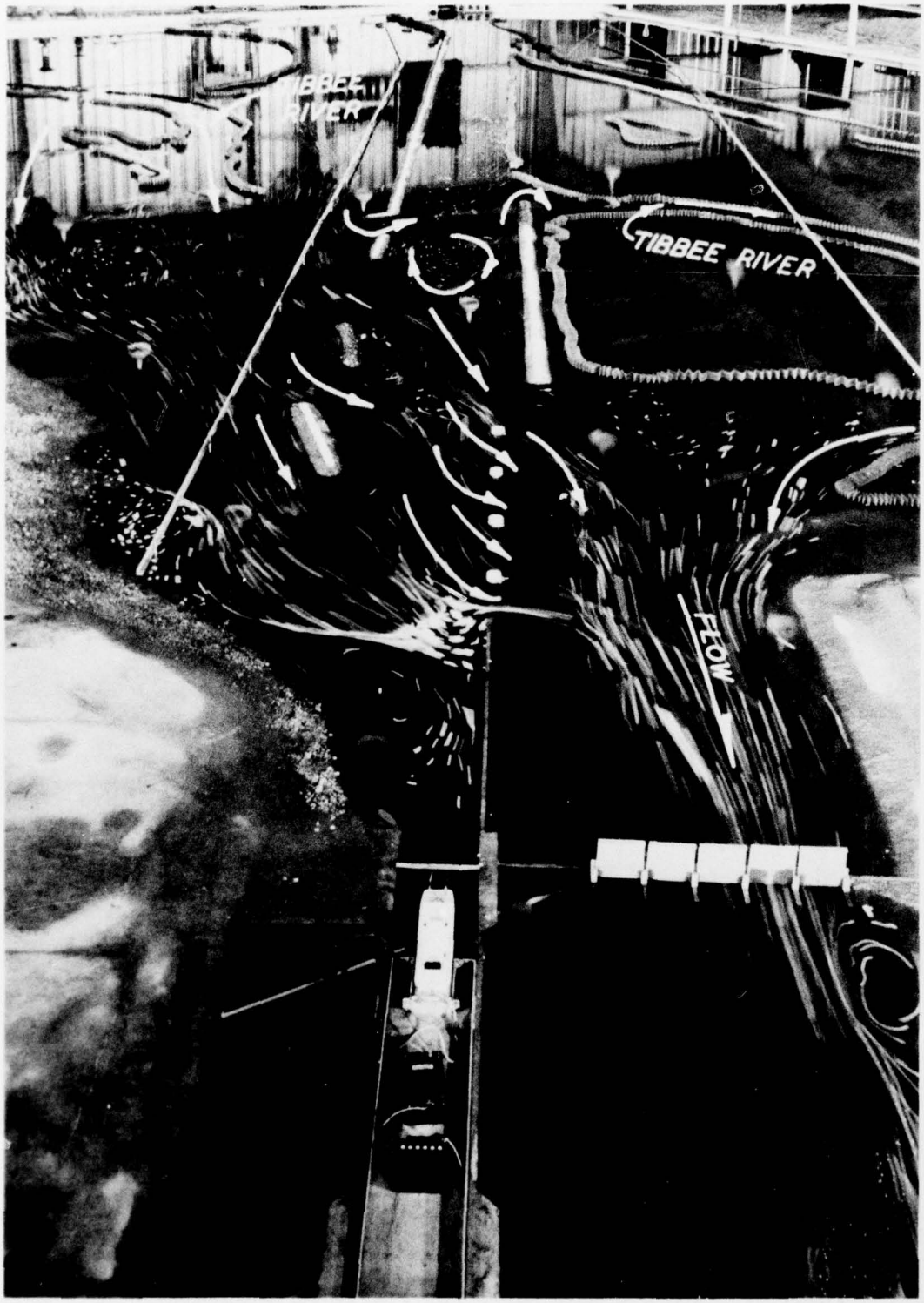


Photo 4. Plan D-2 with 180,000 cfs and upper pool elevation of 172.0. Note surface currents from the right overbank moving toward and across the lock approach

Photo 5. Plan D-2 with discharge 57,000 cfs in Tibbee River and none in Tombigbee River and upper pool elevation of 162.9. Note eddies and intensity of crosscurrents in the lock approach compared with normal distribution of flow (Photo 3)

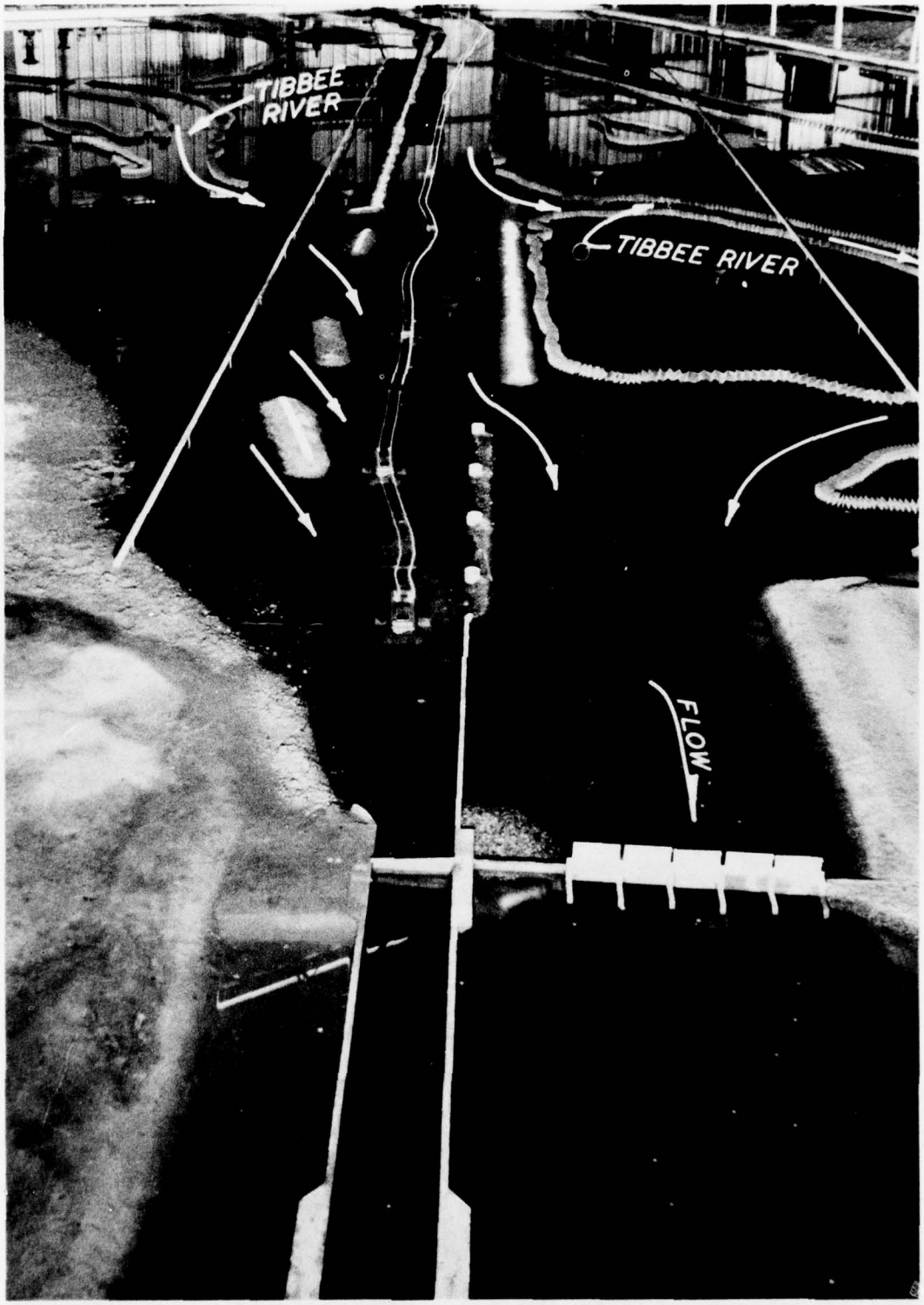


Photo 6. Plan D-2 with discharge of 57,000 cfs and upper pool elevation of 162.9. Note path of downbound tow moving through the lock approach canal and effect of flow from Tibbee River and right overbank on the tow

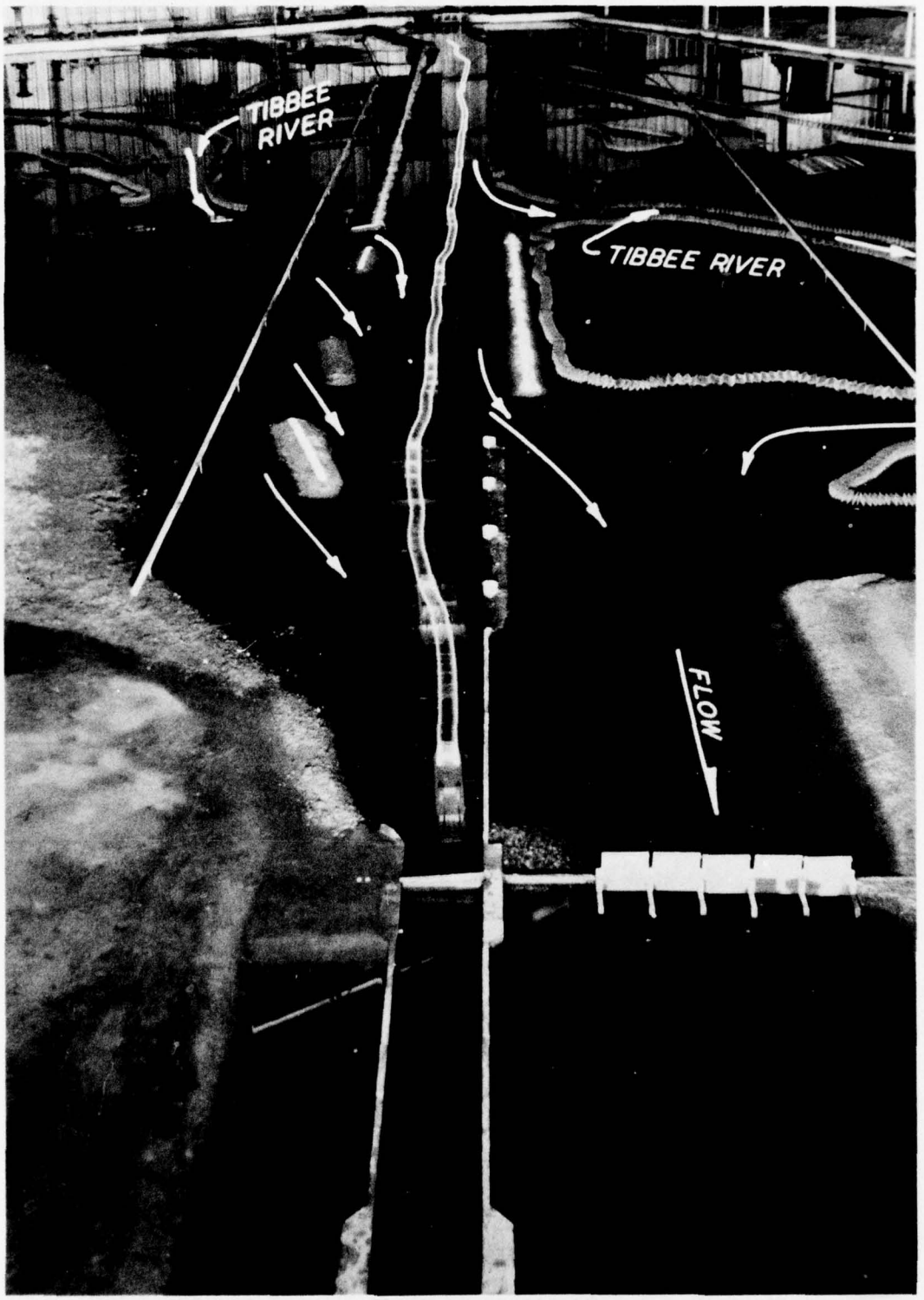


Photo 7. Plan D-2 with discharge of 57,000 cfs and upper pool elevation of 162.9. Note path of upbound tow after leaving the lock based on one-way traffic

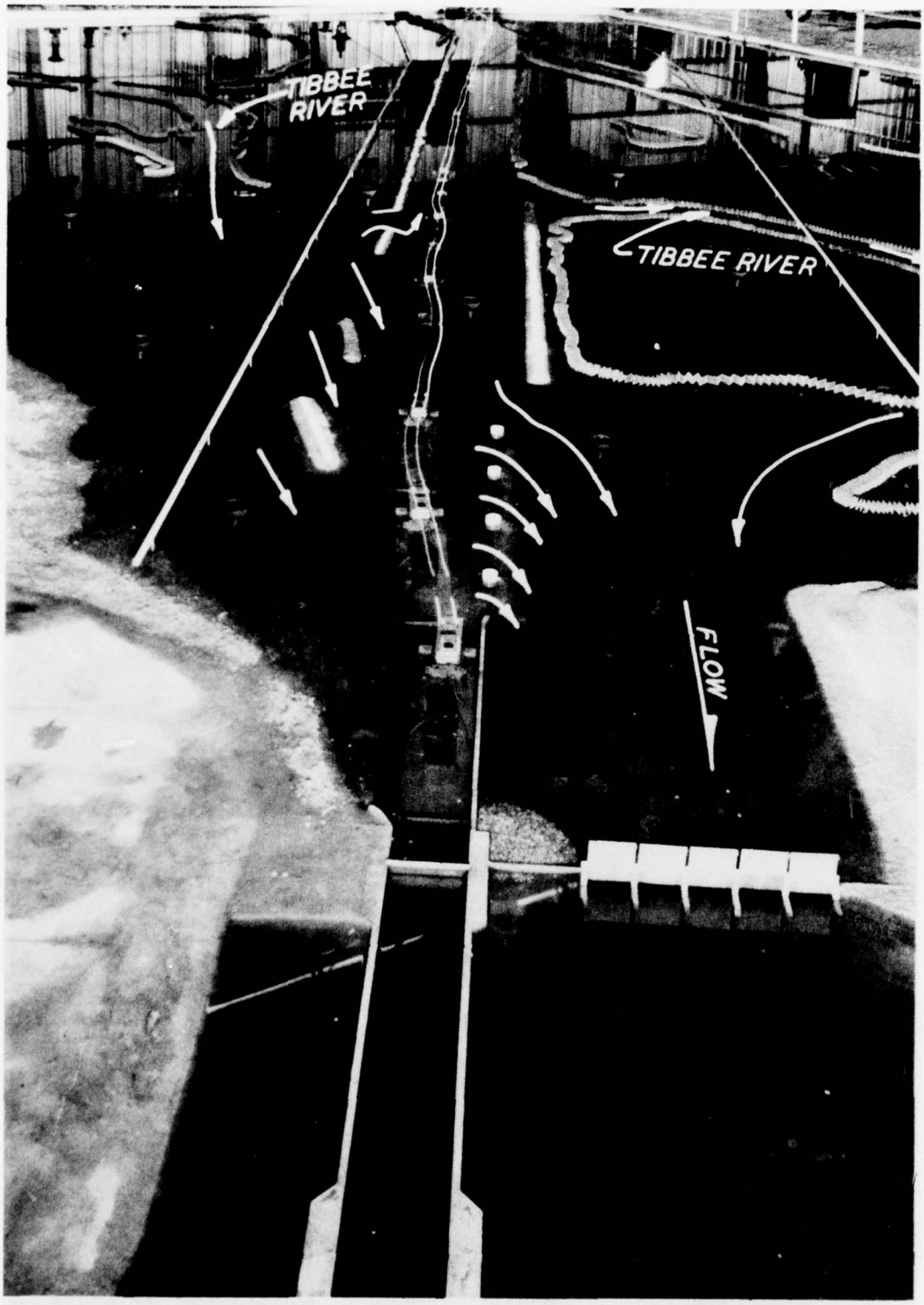


Photo 8. Plan D-2 with discharge of 180,000 cfs and upper pool elevation of 172.0. Note path of downbound tow approaching the lock from the Tombigbee River channel through the lock approach canal

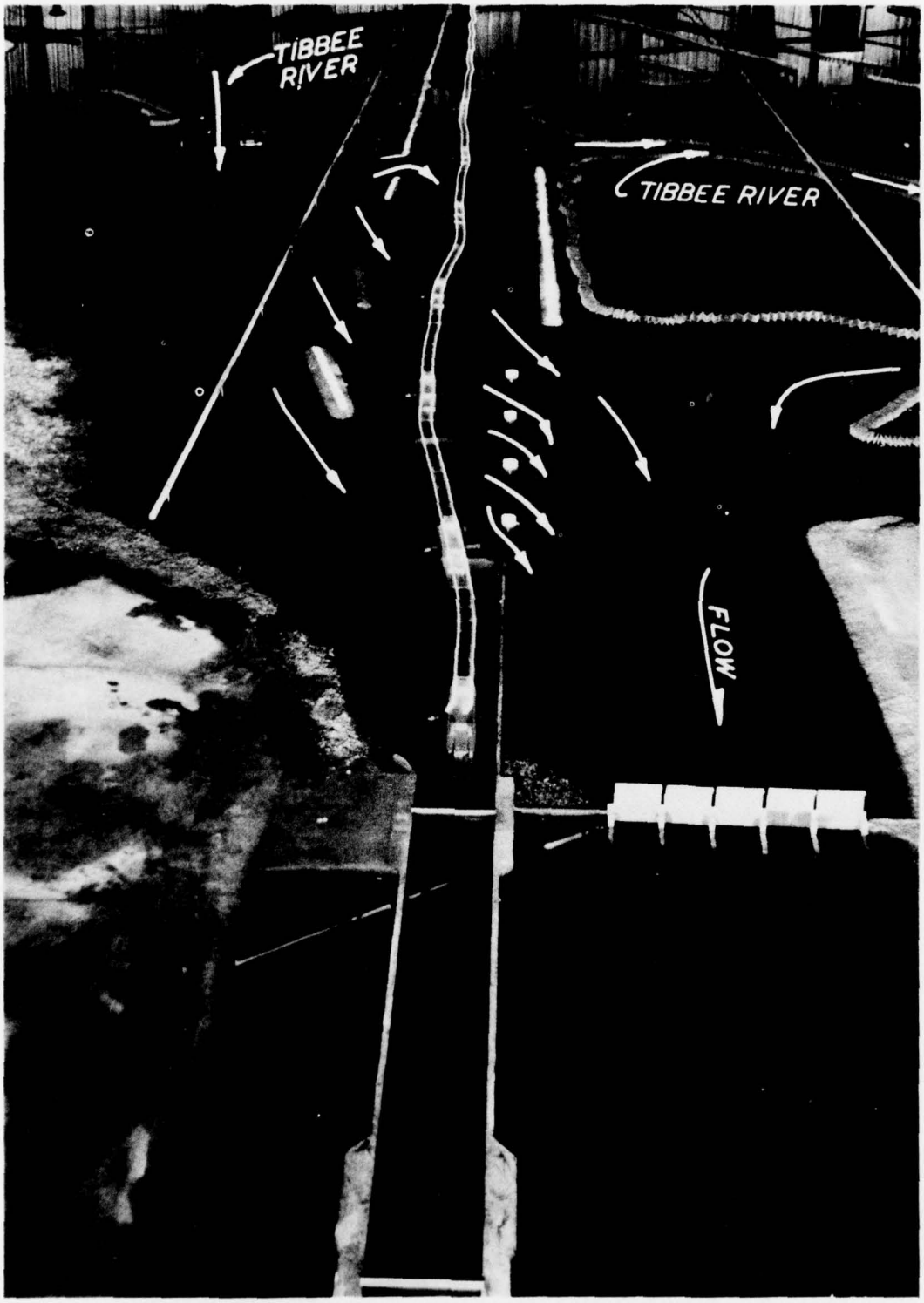


Photo 9. Plan D-2 with discharge of 180,000 cfs and upper pool elevation of 172.0. Note path of upbound tow moving through the lock approach canal after leaving the lock

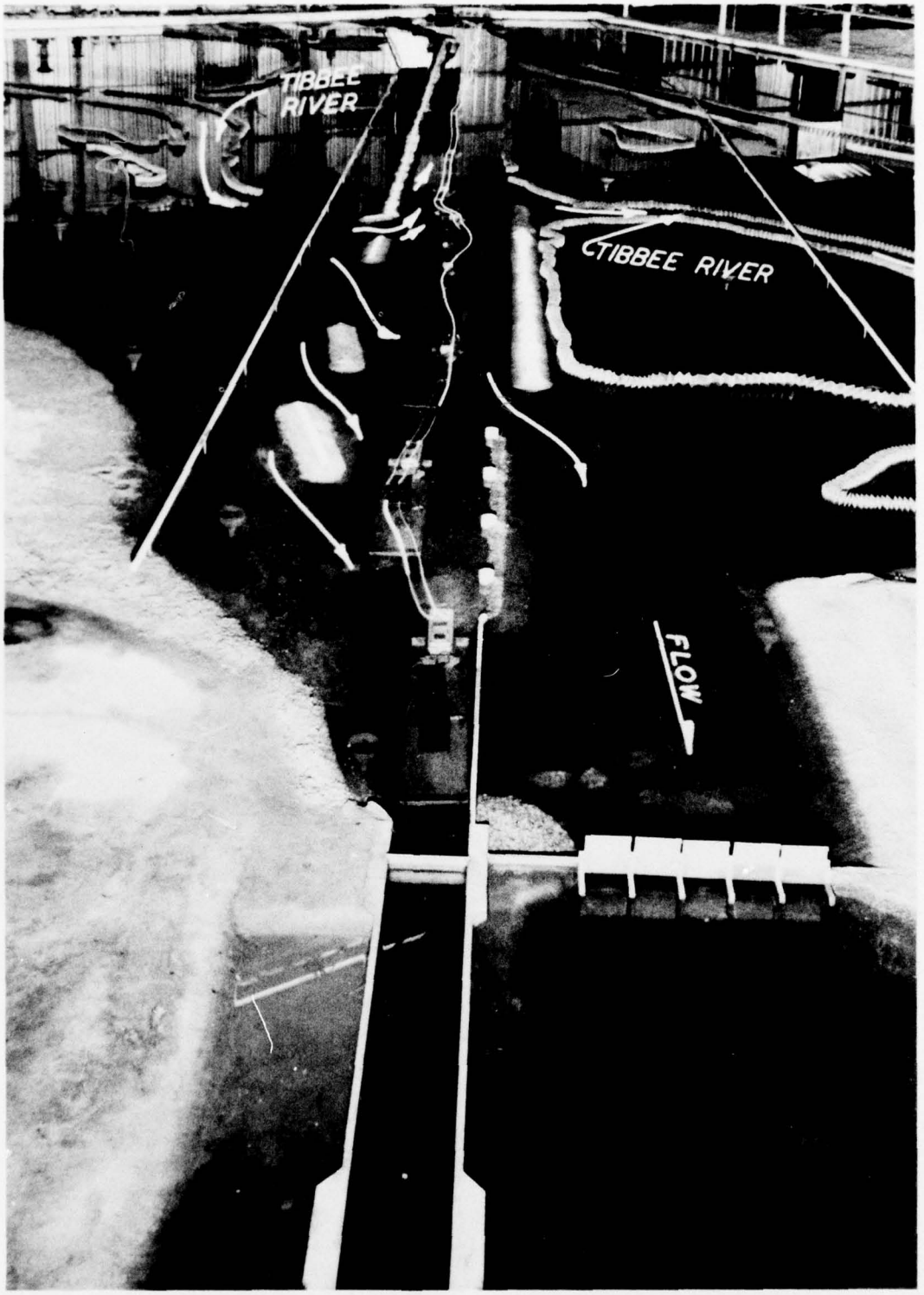


Photo 10. Plan D-2 with discharge of 57,000 cfs and upper pool elevation of 162.9. Note effect of flood on the Tibbee River with little or no flow in the Tombigbee River on the path of a downbound tow approaching the lock. (Compare with normal distribution of flow in Photo 6)

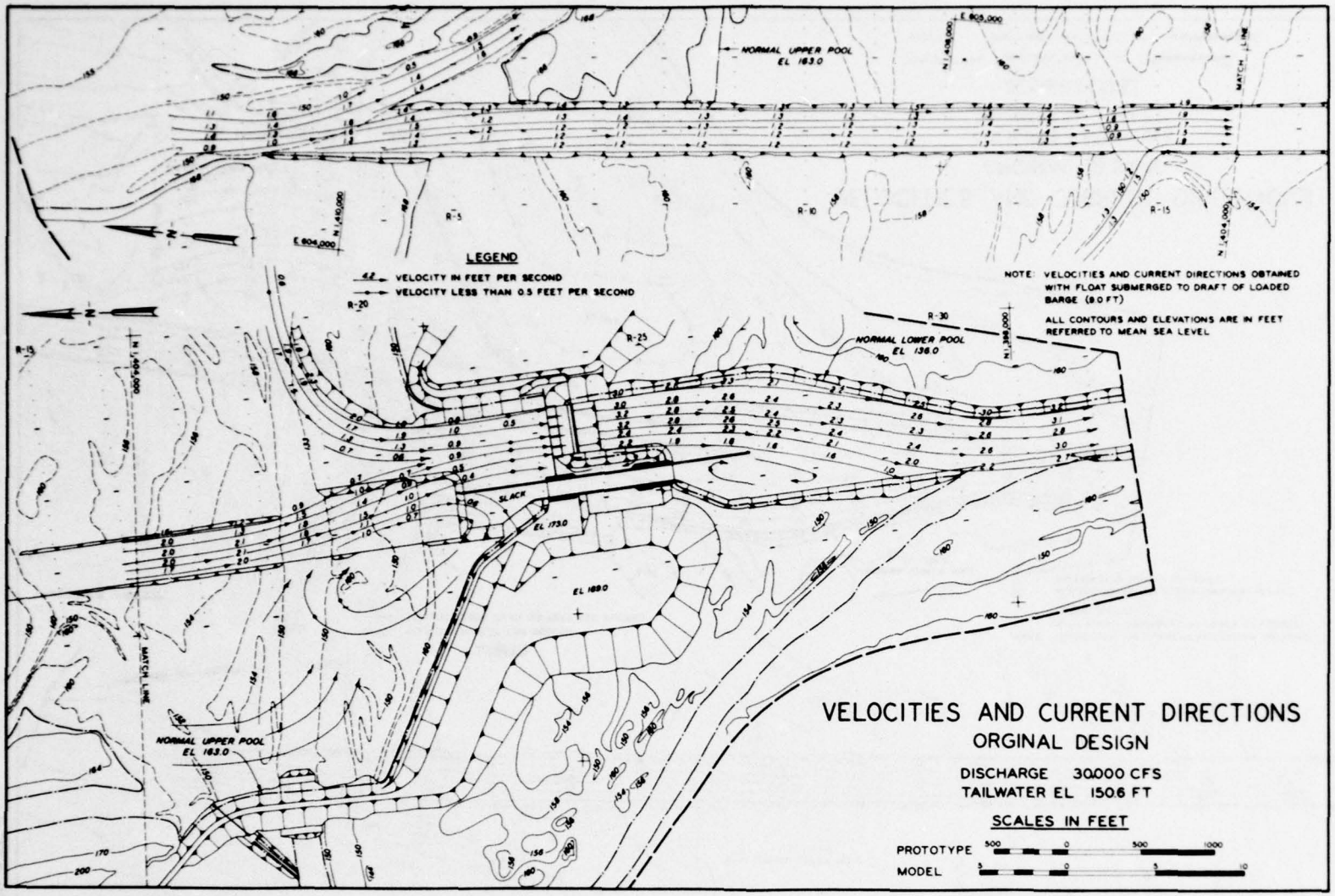
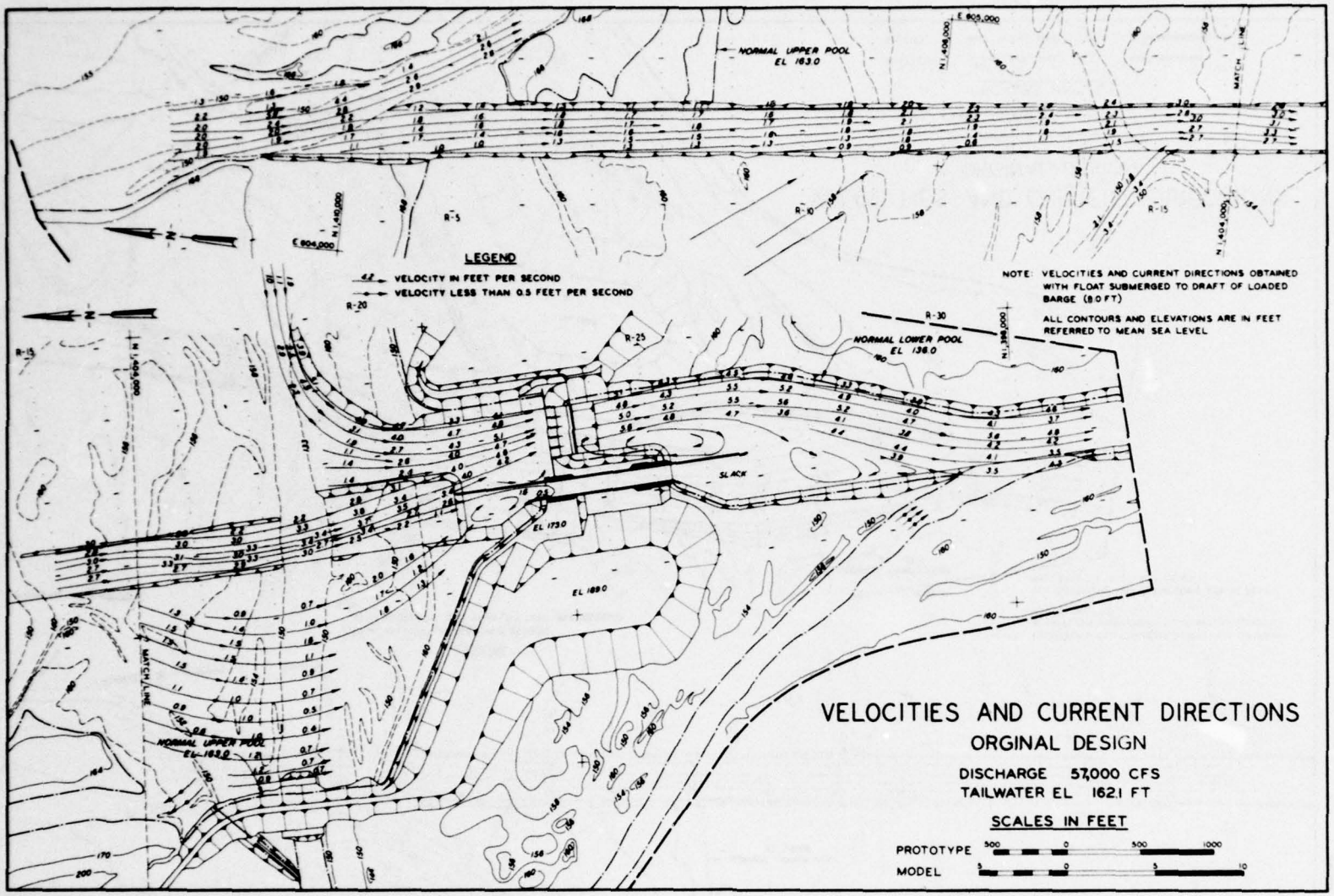

NORMAL UPPER POOL
EL 163.0
LEGEND
.62 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
NORMAL LOWER POOL
EL 136.0
SLACK
EL 173.0
EL 188.0
MATCH LINE
R-5
R-10
R-15
R-20
R-25
R-30
E 804,000
E 805,000
N 1,404,000
N 1,405,000
N 1,406,000
N 1,407,000
N 1,408,000
VELOCITIES AND CURRENT DIRECTIONS
ORGINAL DESIGN
DISCHARGE 30,000 CFS
TAILWATER EL 150.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 1

PLATE 2


NORMAL UPPER POOL
EL 163.0
E 605,000
N 1,406,000
MATCH LINE
E 604,000
N 1,404,000
R-5
R-10
R-15
R-20
R-25
R-30
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (8.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
NORMAL LOWER POOL
EL 136.0
N 1,395,000
SLACK
EL 173.0
EL 169.0
MATCH LINE
NORMAL UPPER POOL
EL 163.0
VELOCITIES AND CURRENT DIRECTIONS
ORGINAL DESIGN
DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

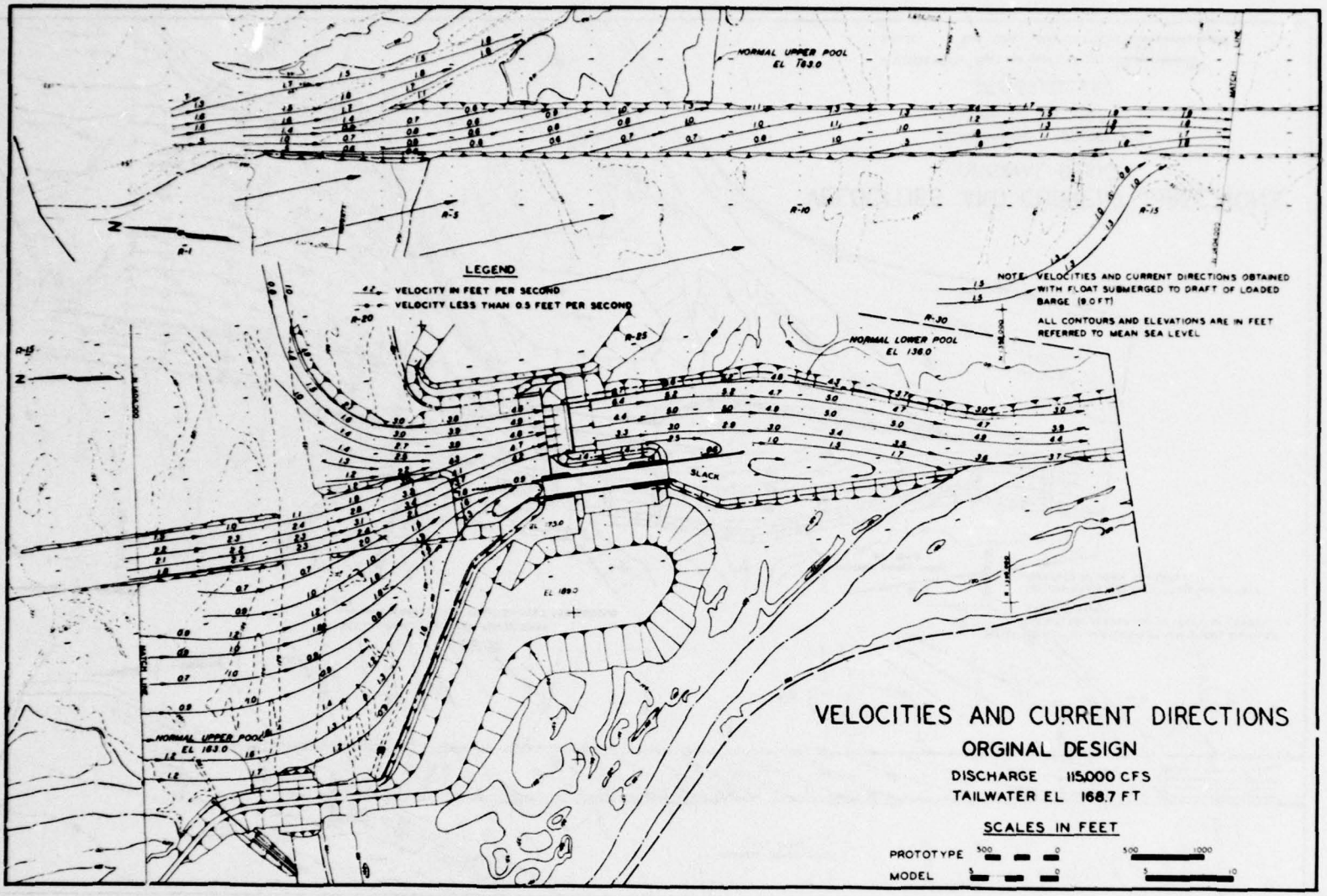
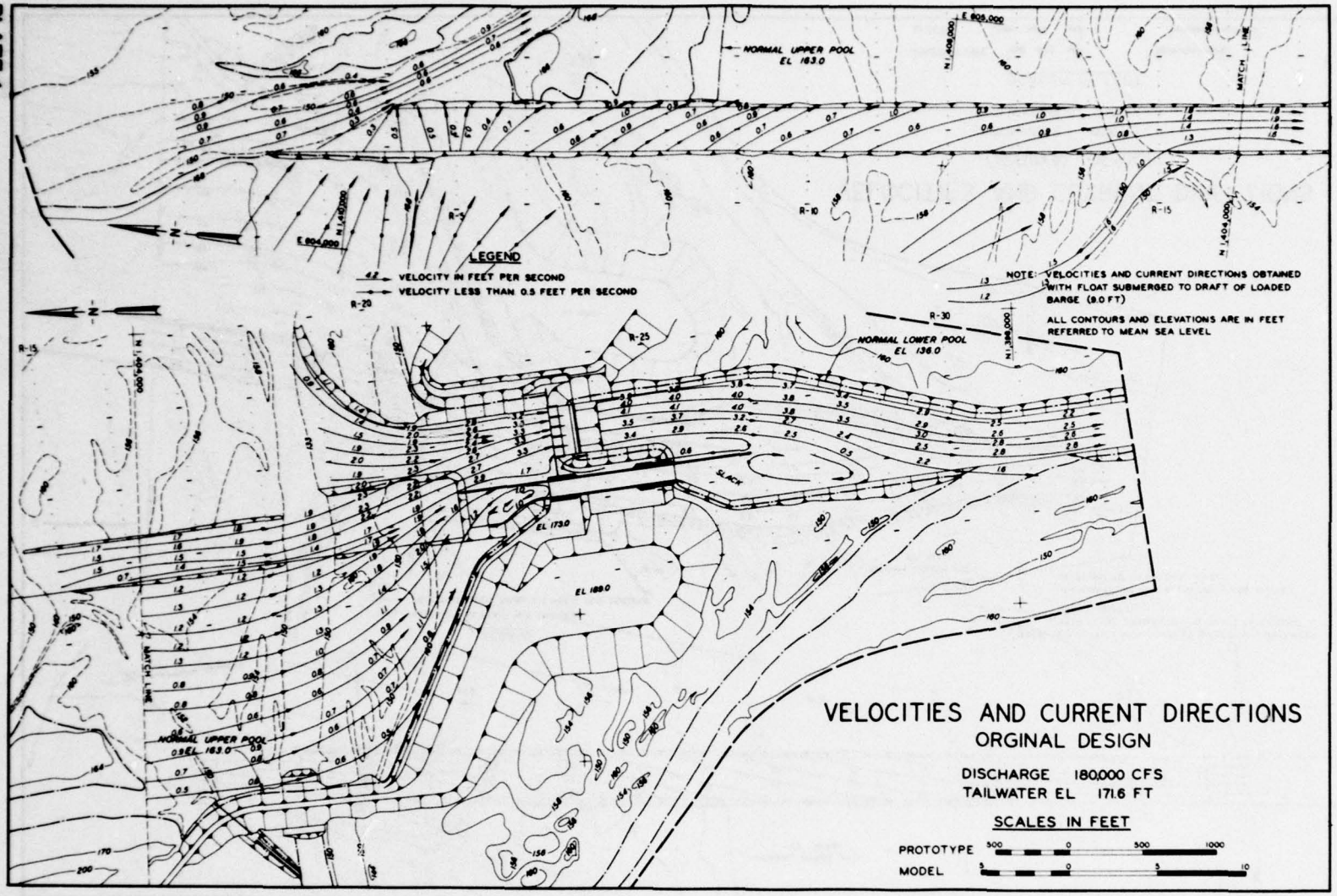
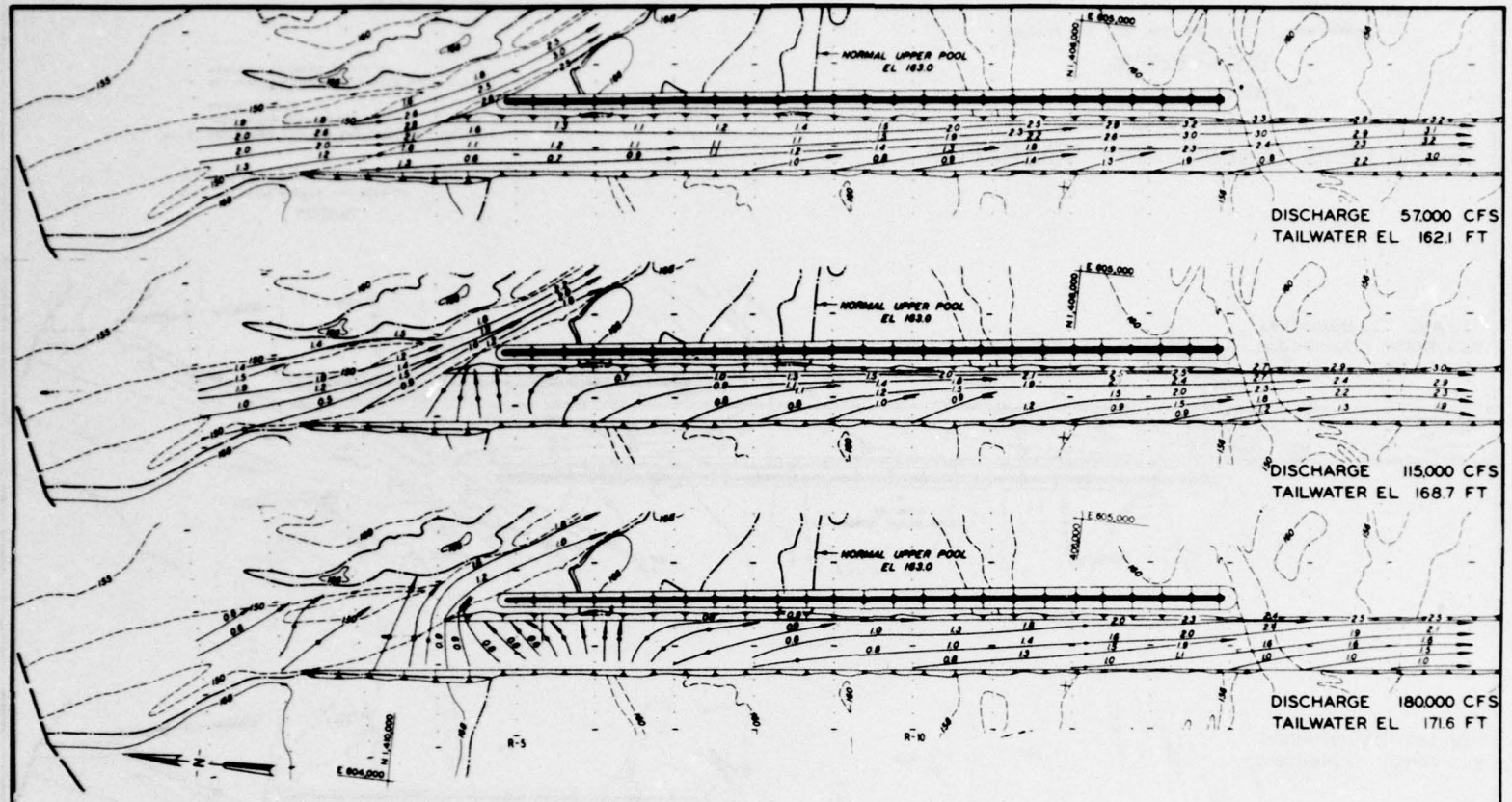

NORMAL UPPER POOL
EL 183.0
NORMAL LOWER POOL
EL 136.0
NORMAL UPPER POOL
EL 183.0
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
SLACK
EL 730
EL 1800
R-1
R-5
R-10
R-15
R-20
R-25
R-30
N
MATCH LINE
VELOCITIES AND CURRENT DIRECTIONS
ORGINAL DESIGN
DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 3

PLATE 4


NORMAL UPPER POOL
EL 183.0
E 805,000
N 1,405,000
MATCH LINE
N 1,403,000
E 804,000
N 1,401,000
R-5
R-10
R-15
R-20
R-25
R-30
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
NORMAL LOWER POOL
EL 136.0
1000 FEET N
SLACK
EL 173.0
EL 188.0
N 1,405,000
MATCH LINE
NORMAL UPPER POOL
EL 183.0
VELOCITIES AND CURRENT DIRECTIONS
ORGINAL DESIGN
DISCHARGE 180,000 CFS
TAILWATER EL 171.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



LEGEND

4.2 VELOCITY IN FEET PER SECOND

VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS
PLAN A
LOCK APPROACH CANAL

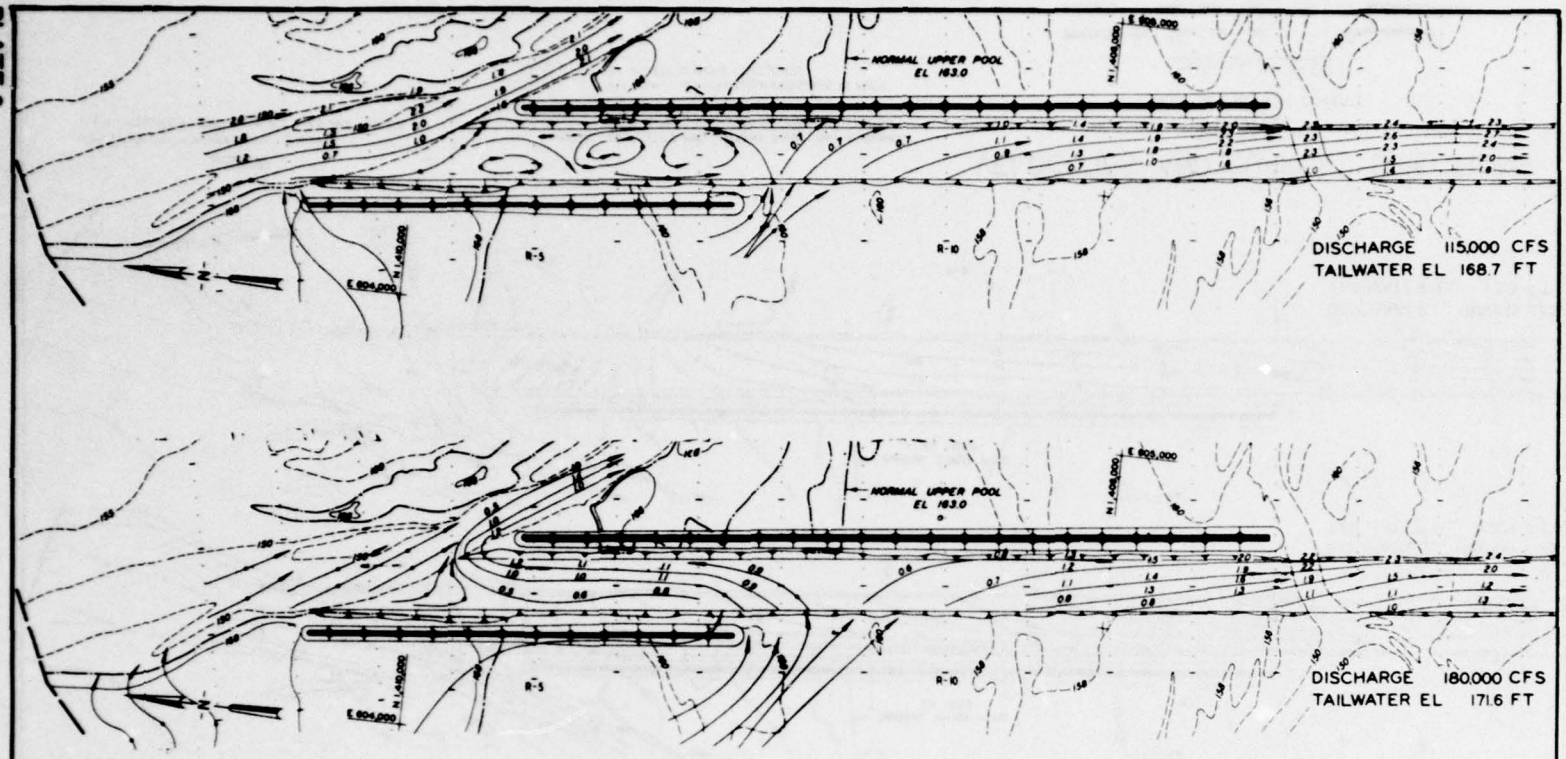
SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

PLATE 5

PLATE 6



LEGEND

42 — VELOCITY IN FEET PER SECOND

→ — VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

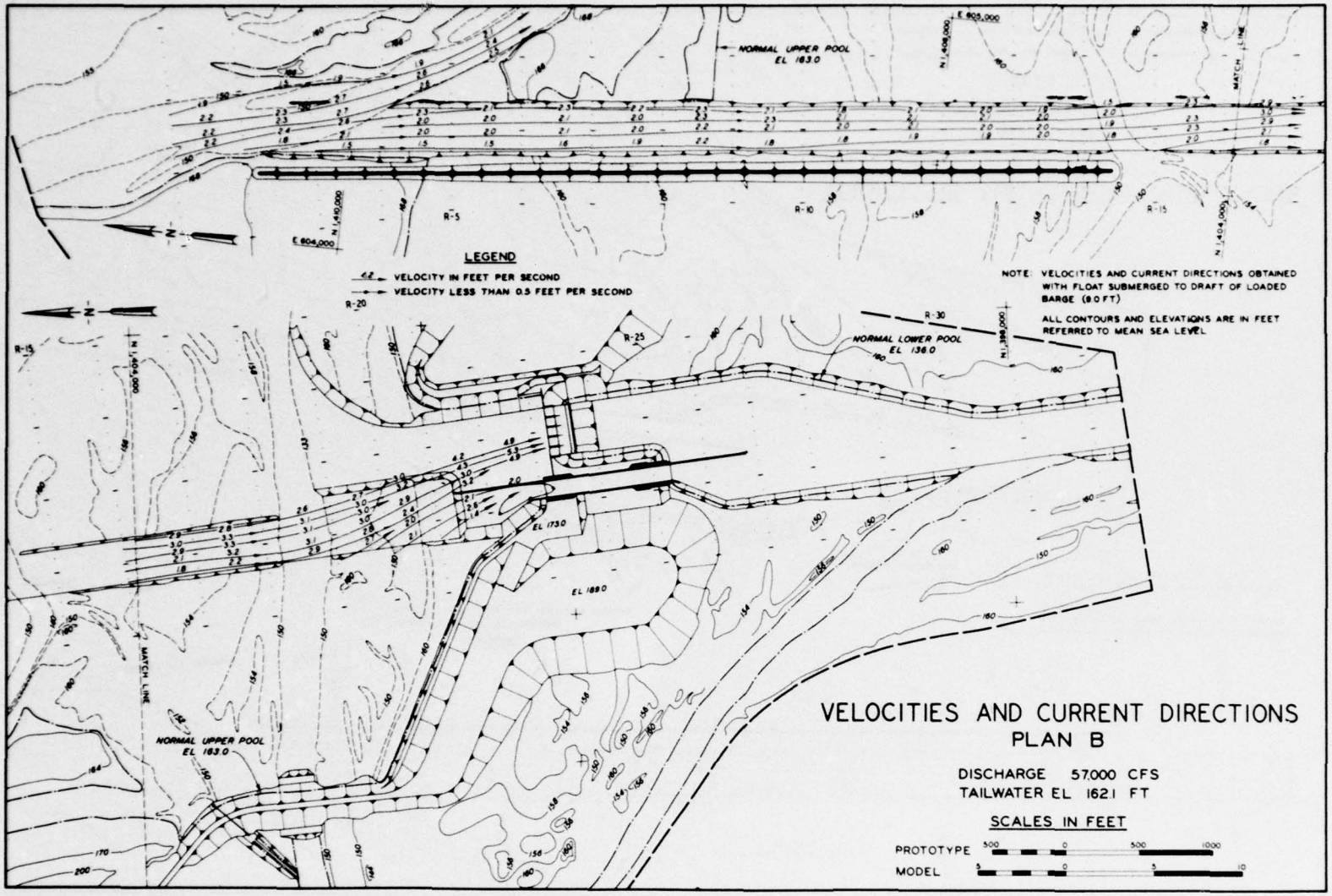
PLAN A-1

LOCK APPROACH CANAL

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



VELOCITIES AND CURRENT DIRECTIONS
PLAN B

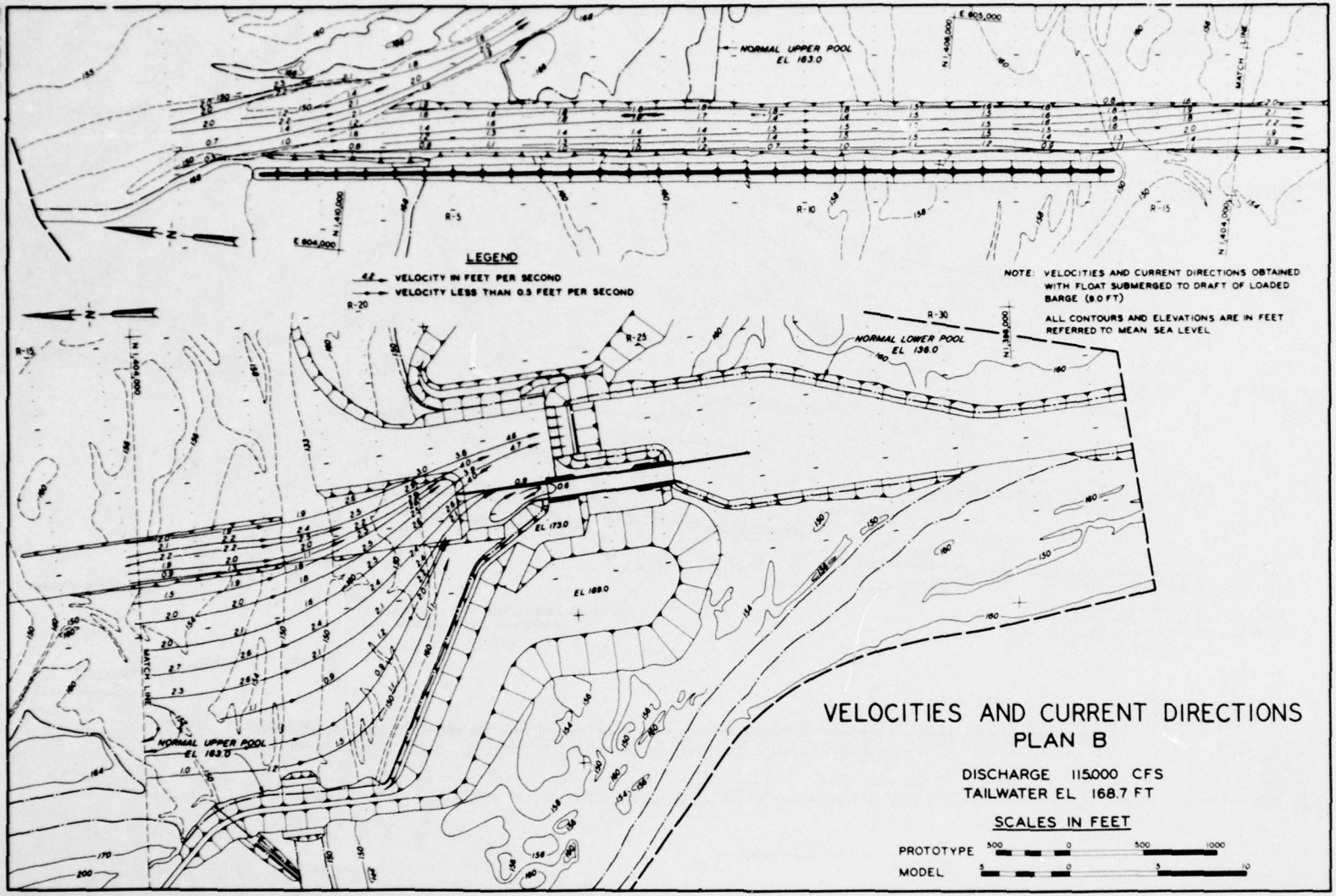
DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 7

PLATE 8



VELOCITIES AND CURRENT DIRECTIONS
PLAN B

DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

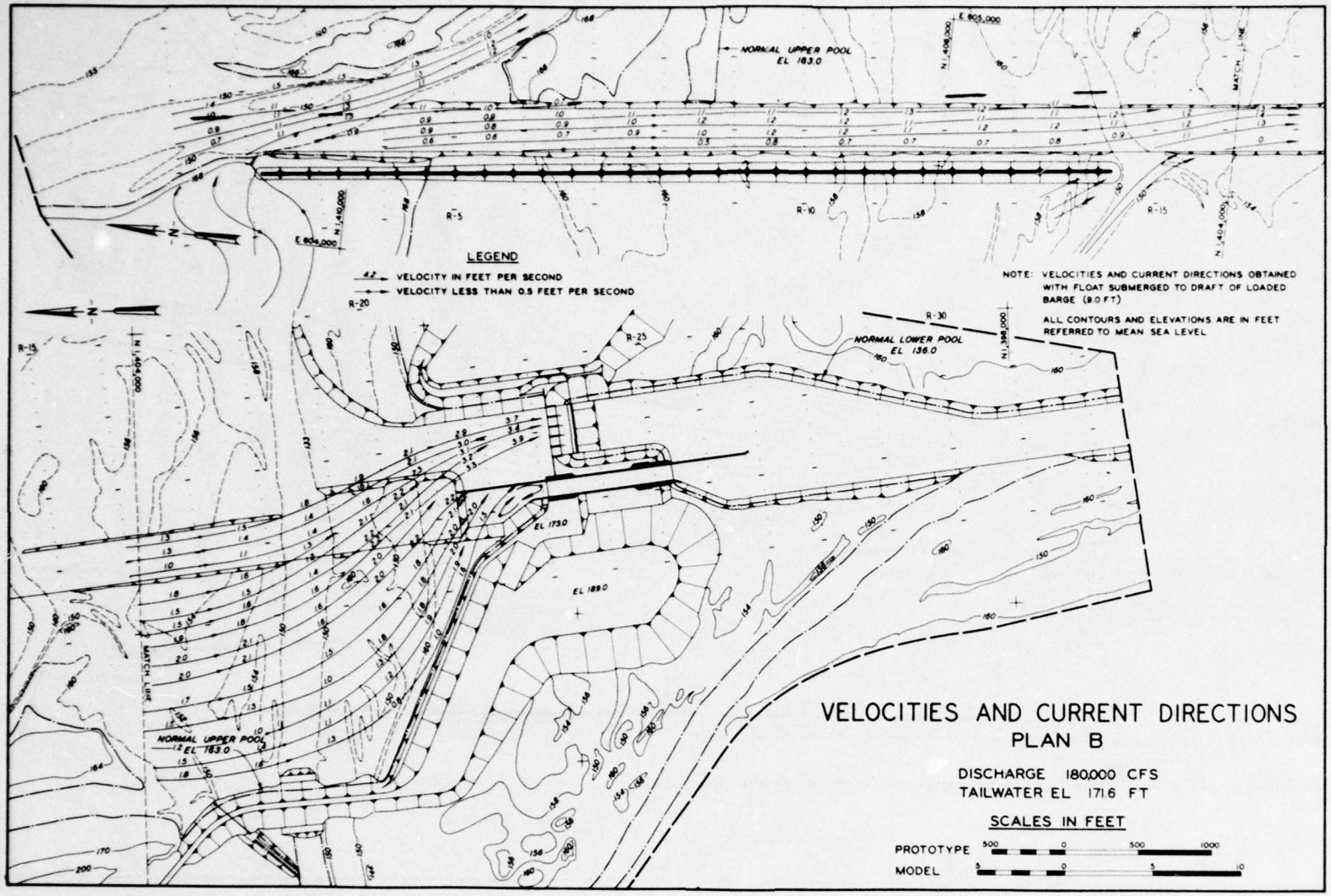
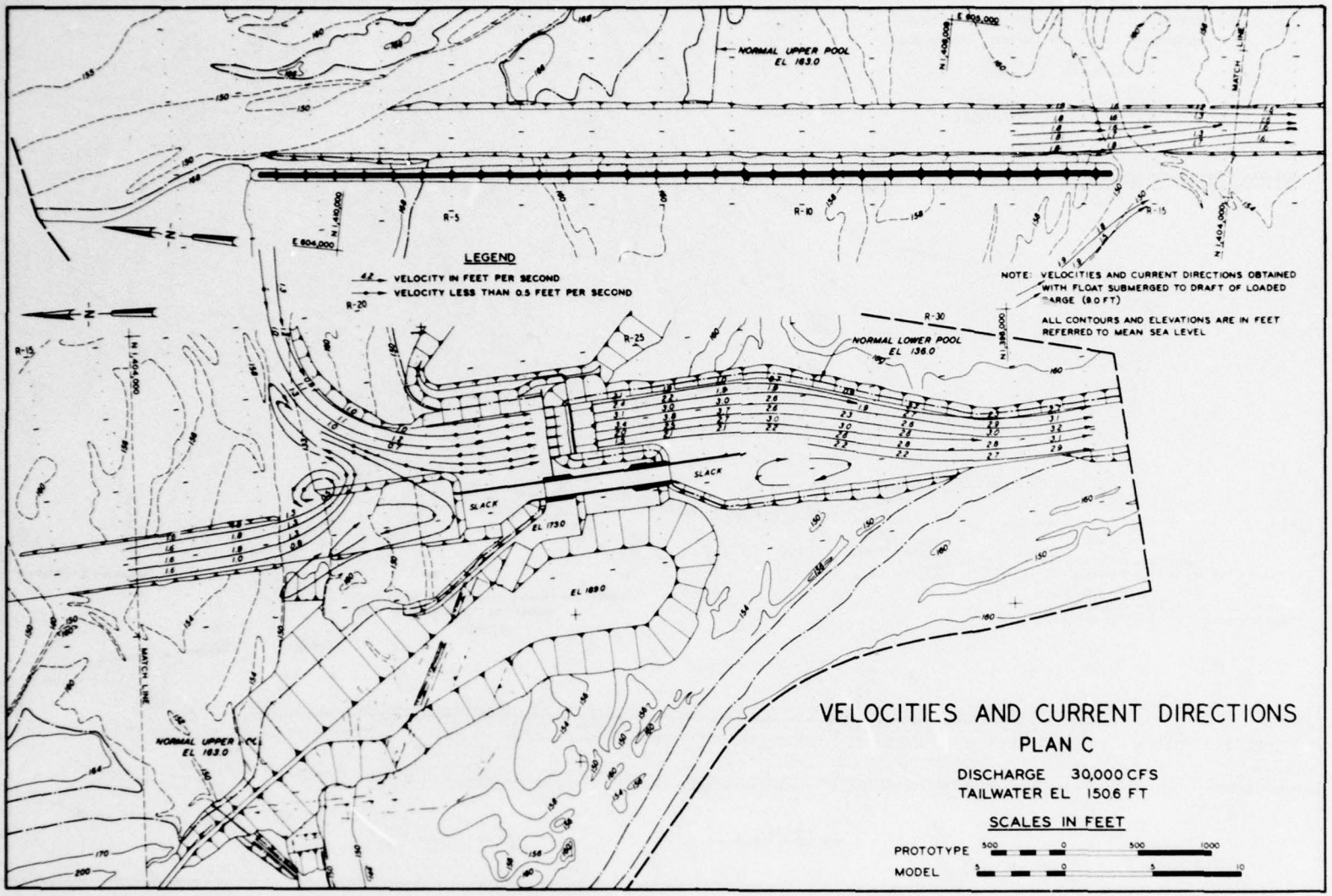

NORMAL UPPER POOL
EL 183.0
E 805,000
N 1,408,000
N 1,404,000
MATCH LINE
R-5
R-10
R-15
E 804,000
N 1,400,000
LEGEND
42 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
R-20
R-25
R-30
NORMAL LOWER POOL
EL 136.0
N 1,396,000
N 1,404,000
EL 173.0
EL 189.0
MATCH LINE
NORMAL UPPER POOL
EL 183.0
VELOCITIES AND CURRENT DIRECTIONS
PLAN B
DISCHARGE 180,000 CFS
TAILWATER EL 171.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 9

PLATE 10



VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE 30,000 CFS
TAILWATER EL 150.6 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

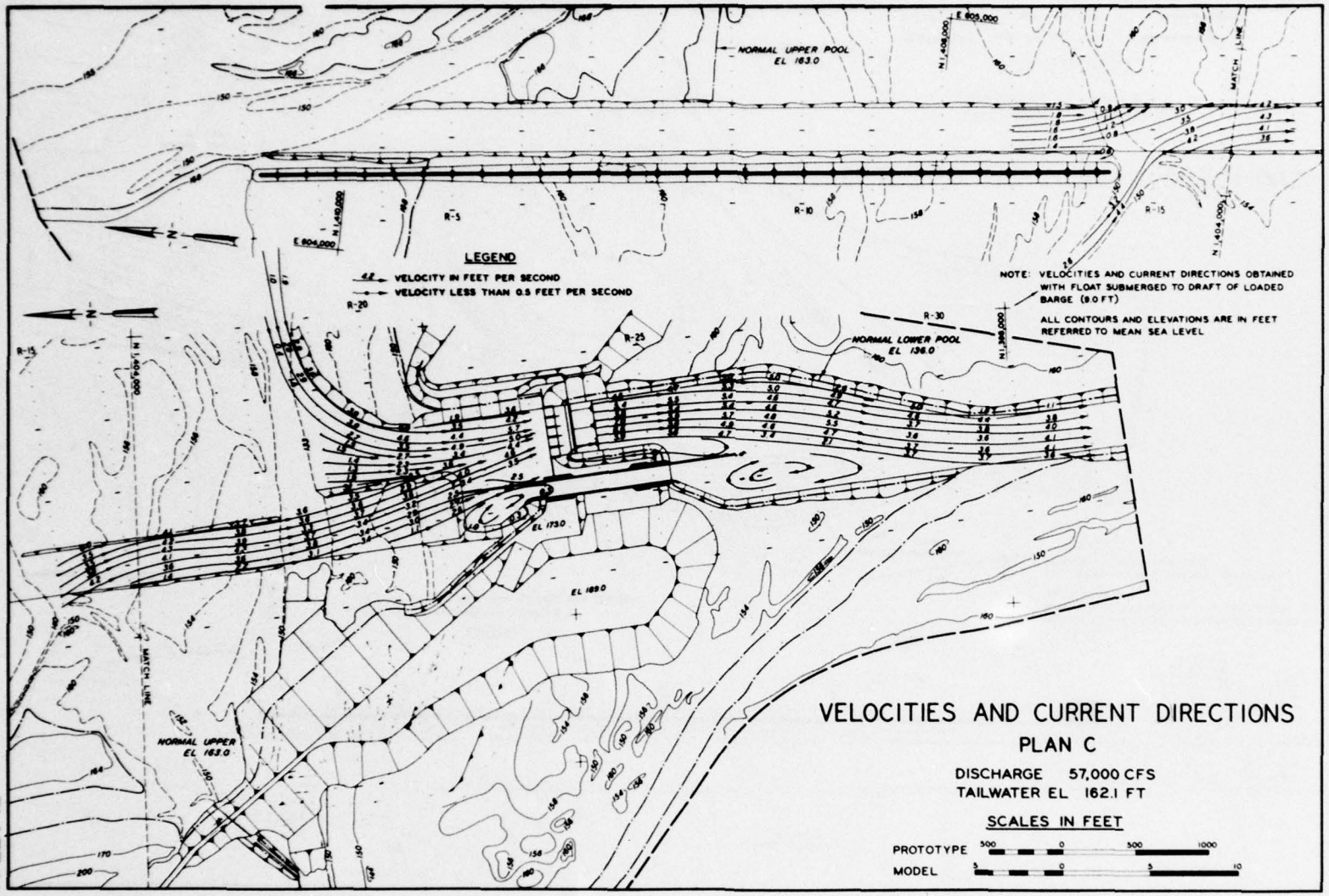
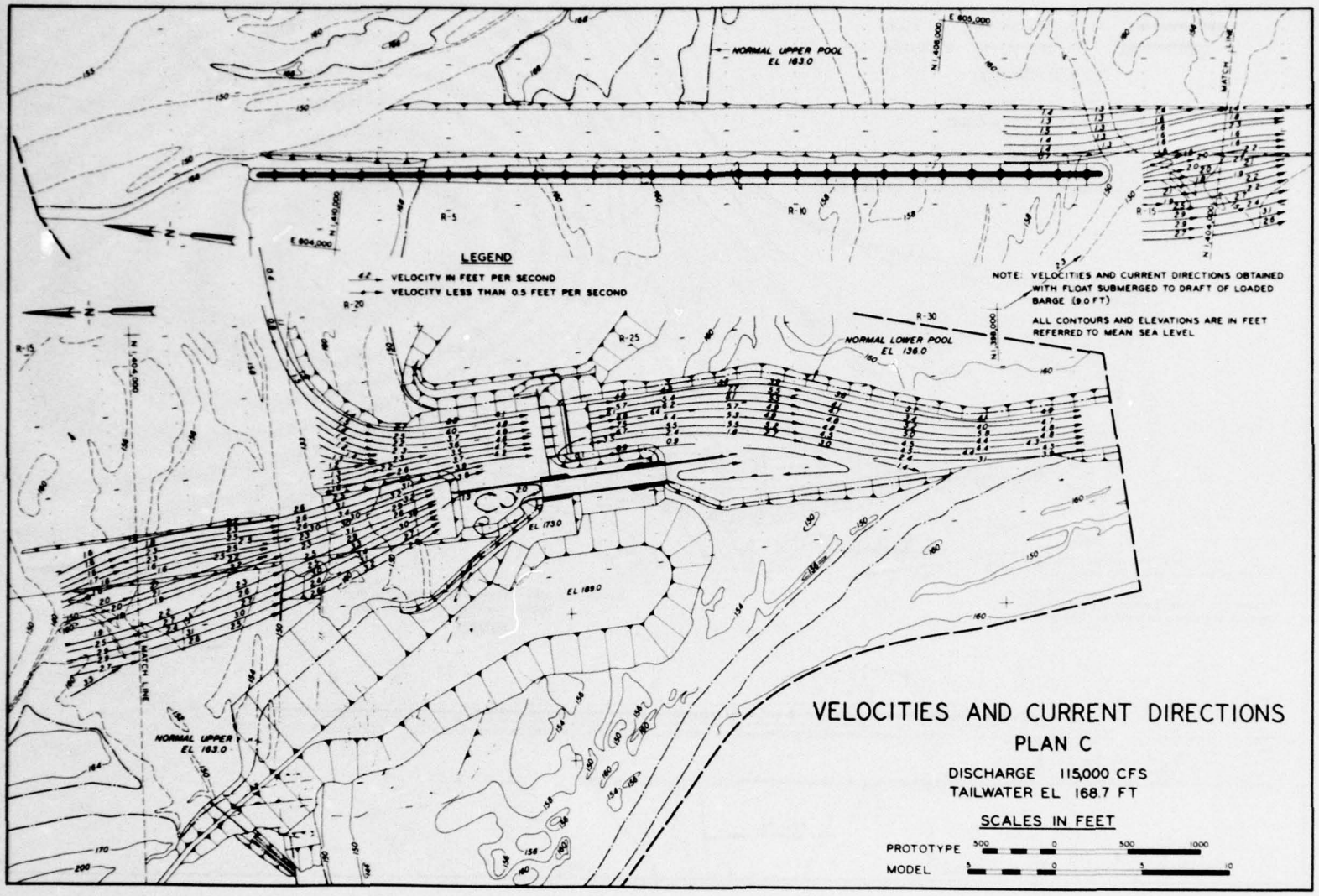

NORMAL UPPER POOL
EL 163.0
E 805,000
N 1,408,000
MATCH LINE
E 804,000
N 1,400,000
N 1,404,000
R-5
R-10
R-15
R-20
R-25
R-30
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
NORMAL LOWER POOL
EL 136.0
EL 173.0
EL 189.0
NORMAL UPPER
EL 163.0
VELOCITIES AND CURRENT DIRECTIONS
PLAN C
DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 11

PLATE 12



VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

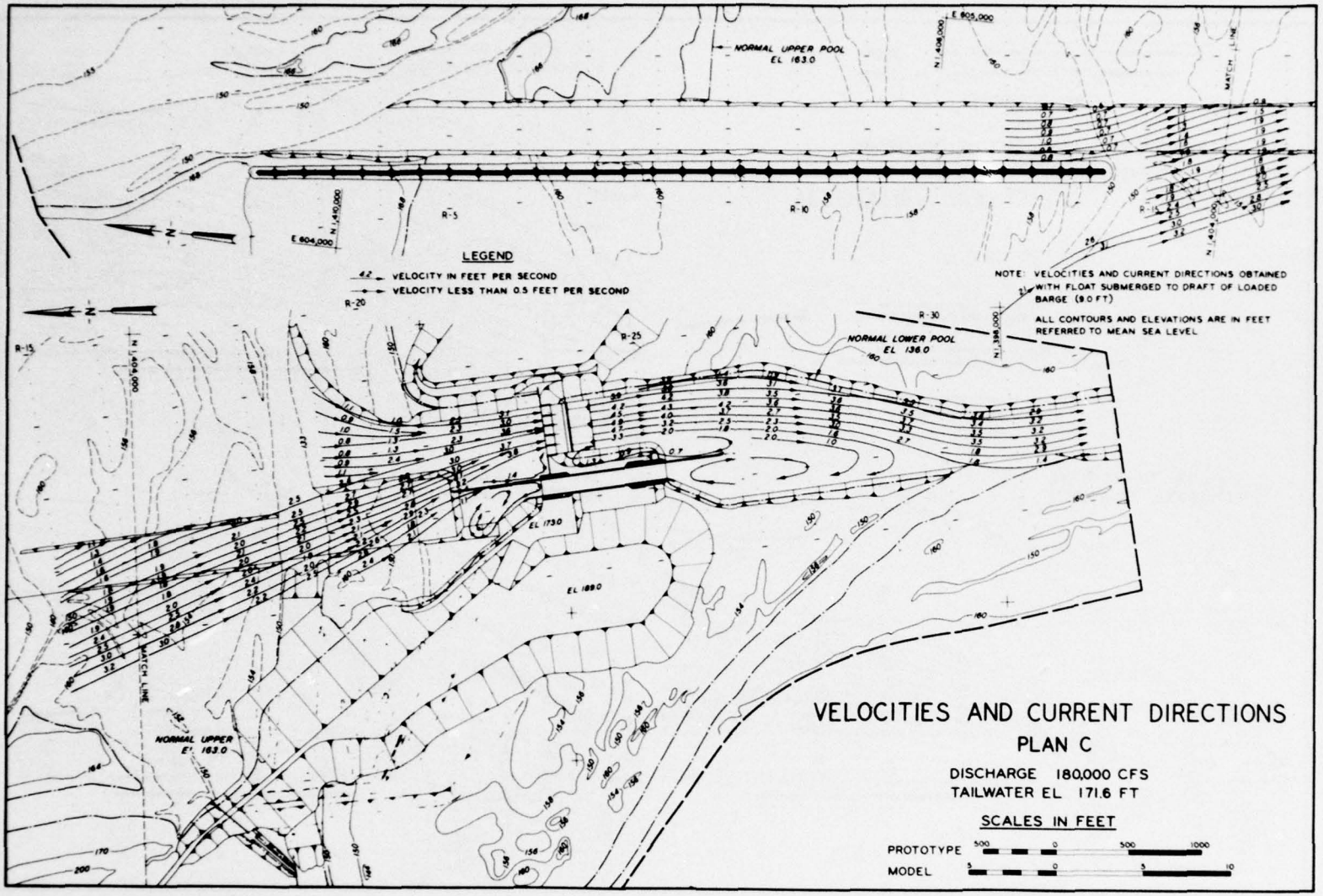
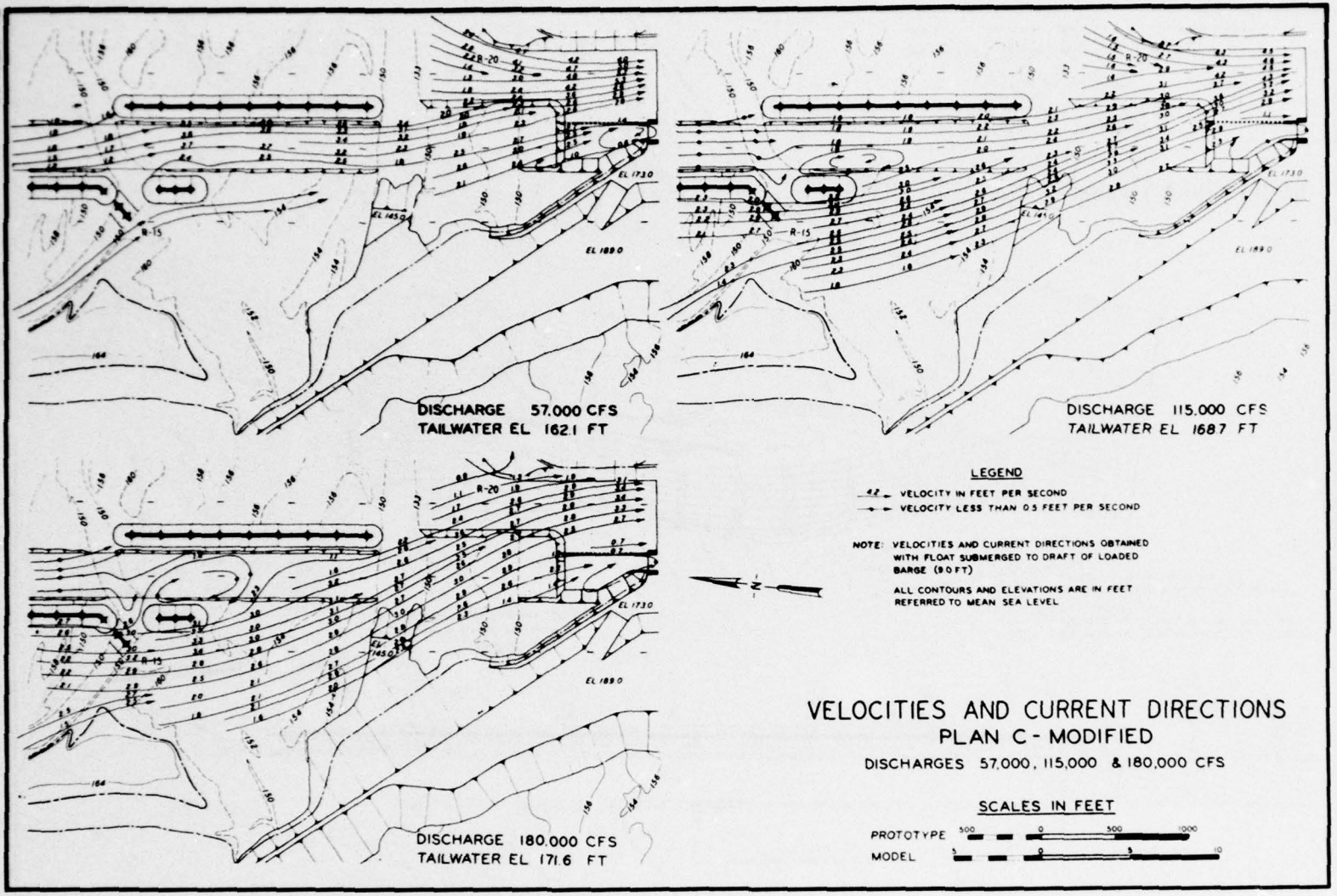

NORMAL UPPER POOL
EL 163.0
E 805,000
N 1,406,000
MATCH LINE
E 804,000
N 1,405,000
R-5
R-10
R-15
R-20
R-25
R-30
LEGEND
4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
NORMAL LOWER POOL
EL 136.0
EL 173.0
EL 189.0
NORMAL UPPER
EL 163.0
VELOCITIES AND CURRENT DIRECTIONS
PLAN C
DISCHARGE 180,000 CFS
TAILWATER EL 171.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 13

PLATE 14



VELOCITIES AND CURRENT DIRECTIONS
PLAN C - MODIFIED
DISCHARGES 57,000, 115,000 & 180,000 CFS

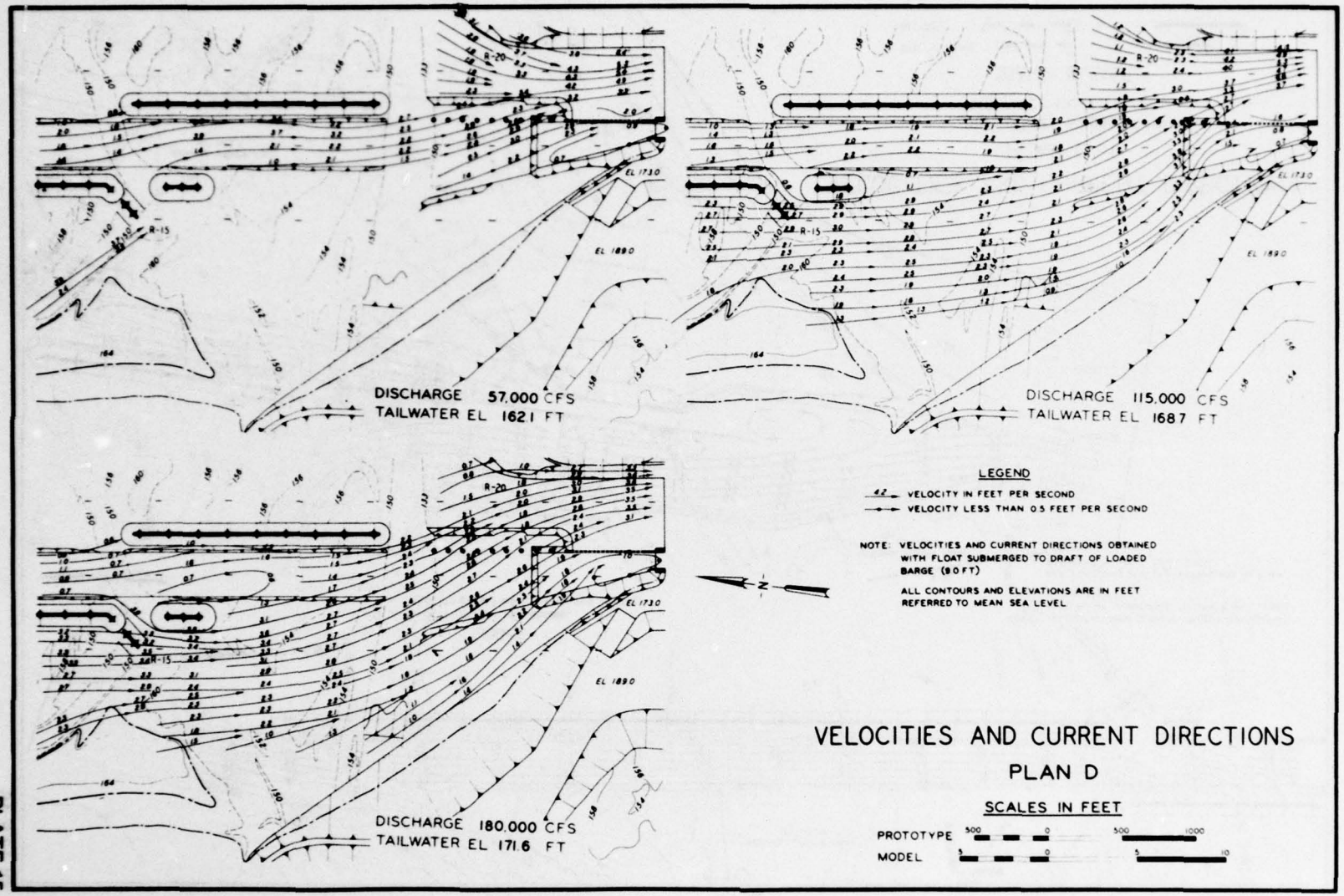
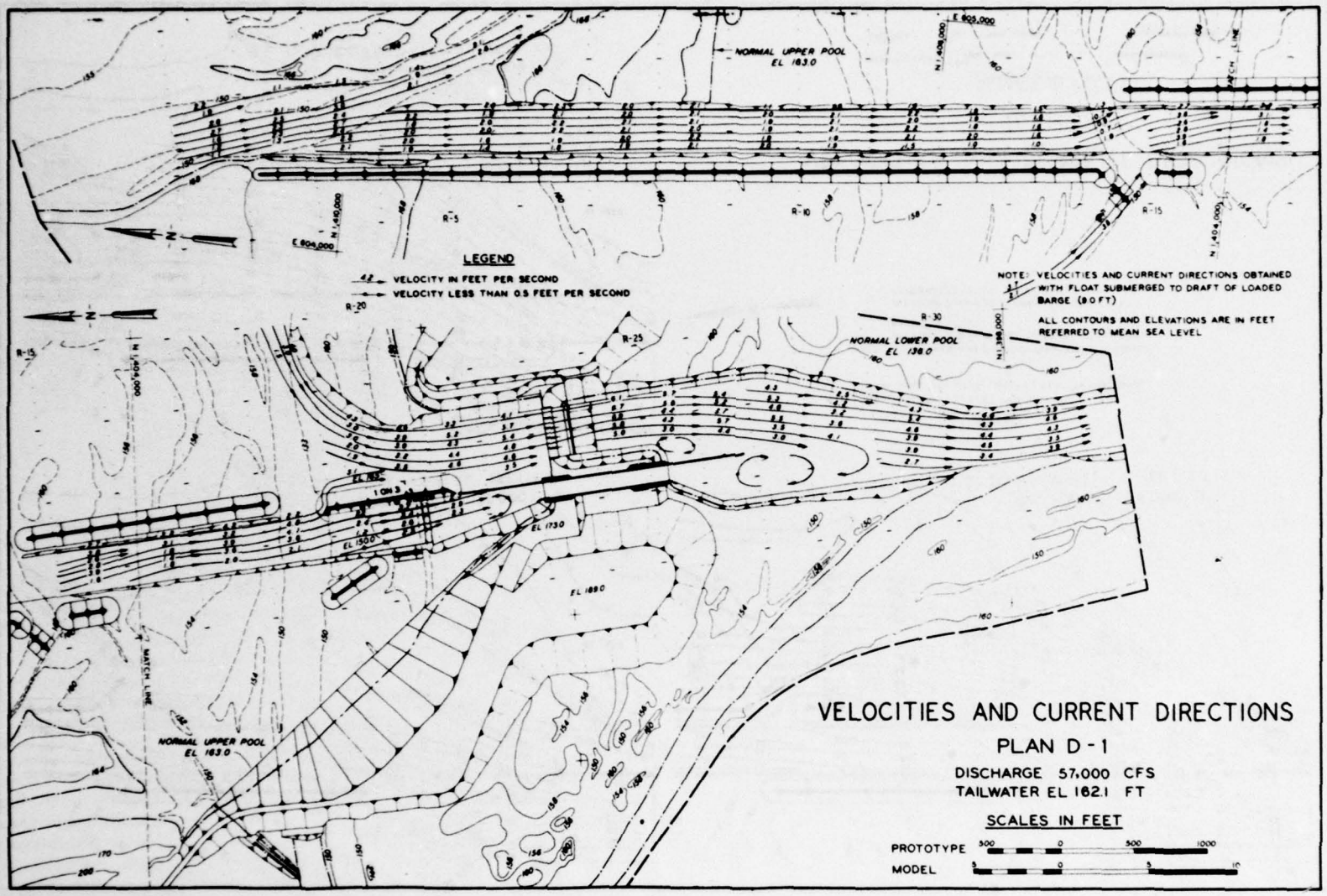

DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT
DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT
DISCHARGE 180,000 CFS
TAILWATER EL 171.6 FT
R-20
R-15
EL 1730
EL 1890
LEGEND
42 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
N
VELOCITIES AND CURRENT DIRECTIONS
PLAN D
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 15

PLATE 16



VELOCITIES AND CURRENT DIRECTIONS

PLAN D-1

DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

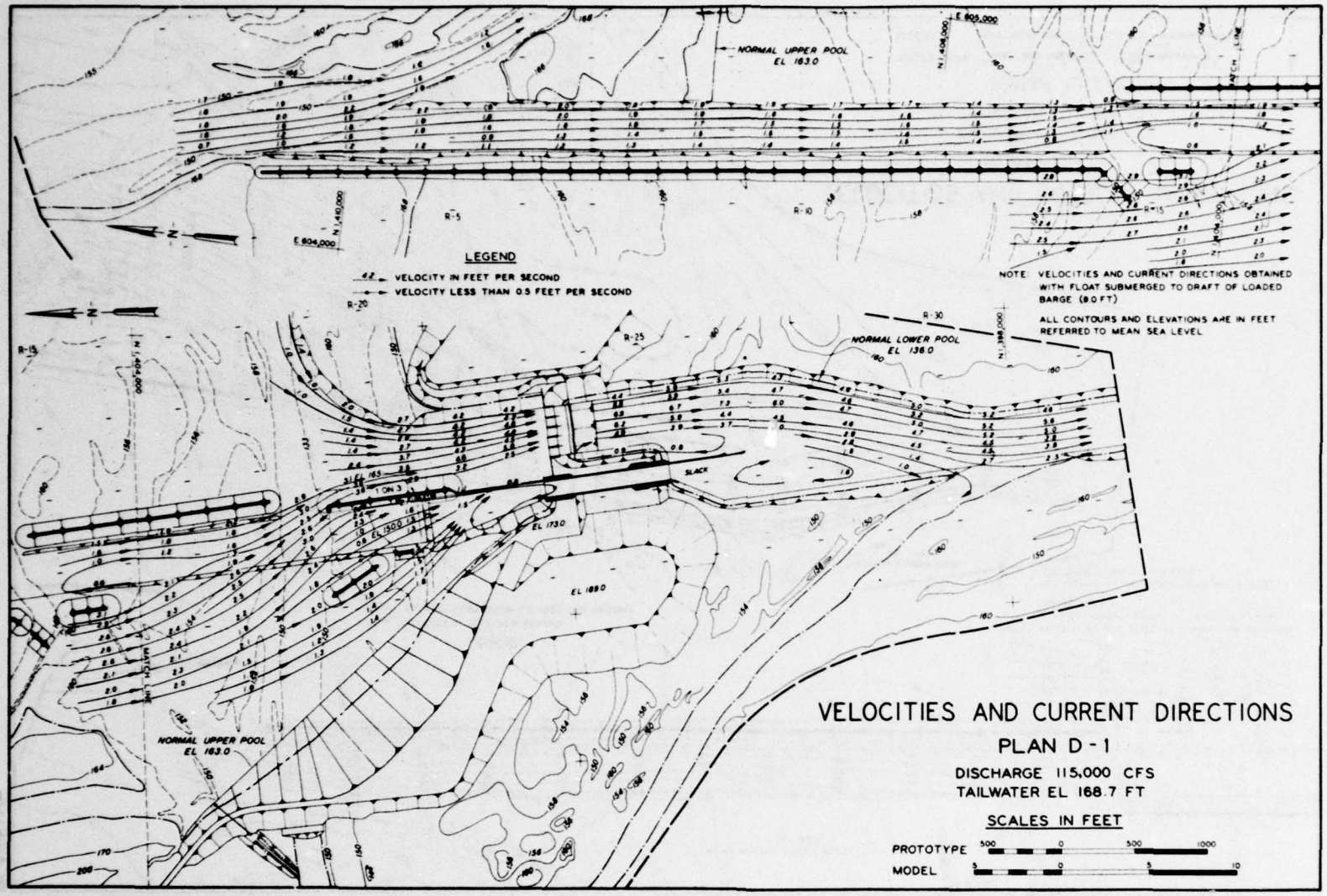
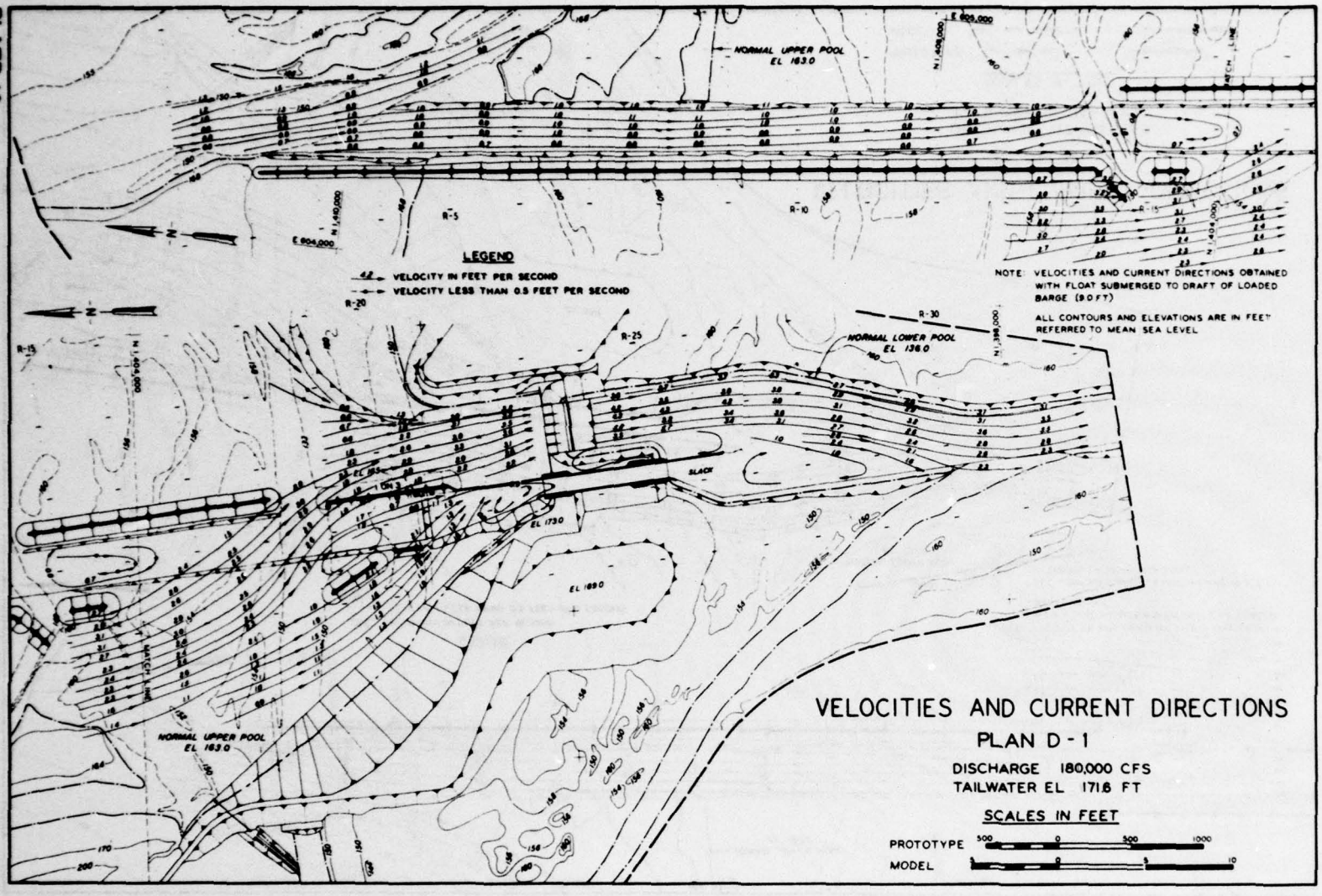

NORMAL UPPER POOL
EL 163.0
E 805,000
N 408,000
E 804,000
N 410,000
R-5
R-10
R-15
R-20
R-25
R-30
N 404,000
N 398,000
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
NORMAL LOWER POOL
EL 138.0
SLACK
EL 173.0
EL 189.0
EL 150.0
MATCH LINE
NORMAL UPPER POOL
EL 163.0
VELOCITIES AND CURRENT DIRECTIONS
PLAN D-1
DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 17

PLATE 18



VELOCITIES AND CURRENT DIRECTIONS

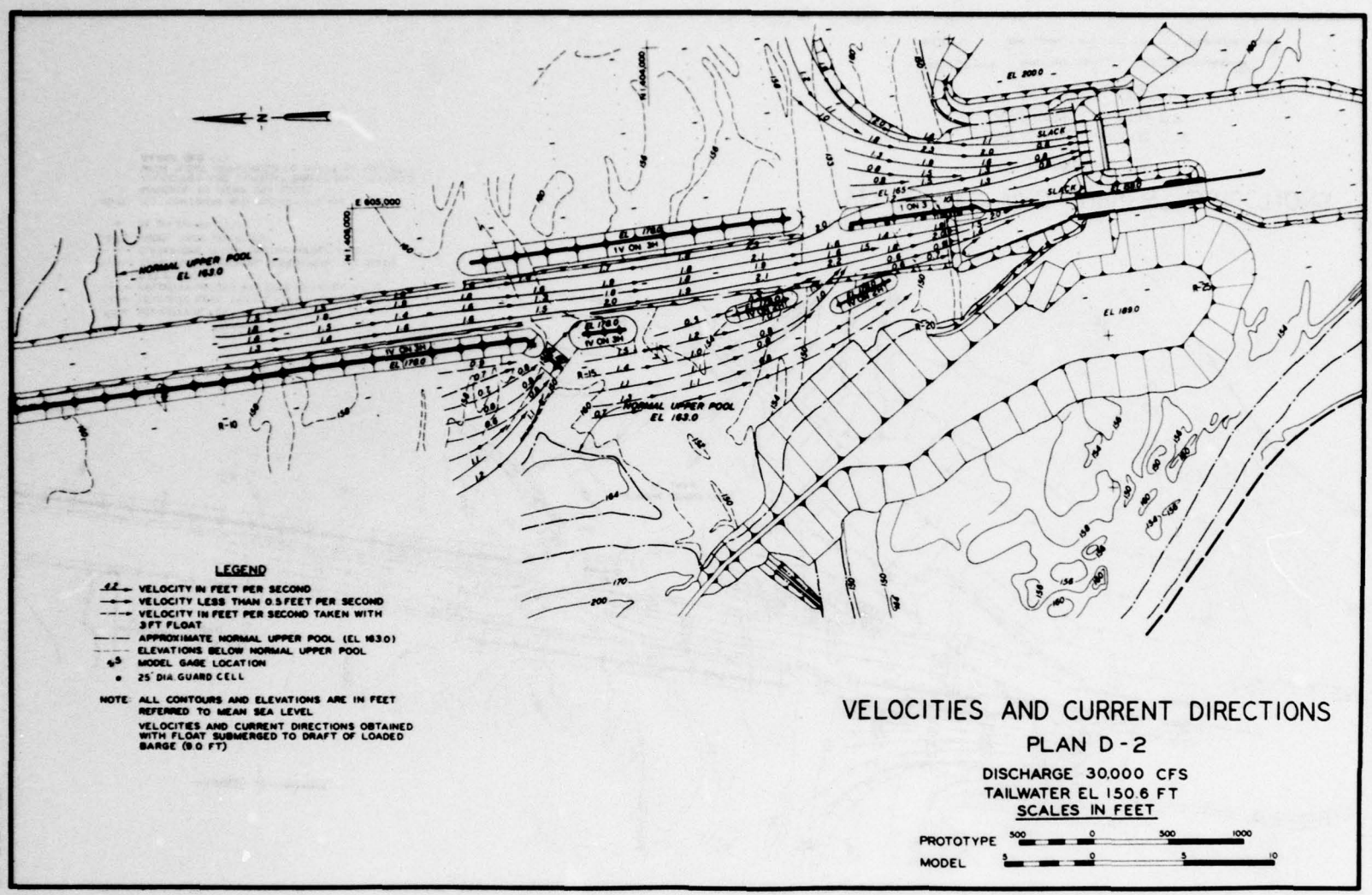
PLAN D - 1

DISCHARGE 180,000 CFS
TAILWATER EL 1718 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



VELOCITIES AND CURRENT DIRECTIONS

PLAN D-2

DISCHARGE 30,000 CFS

TAILWATER EL 150.6 FT

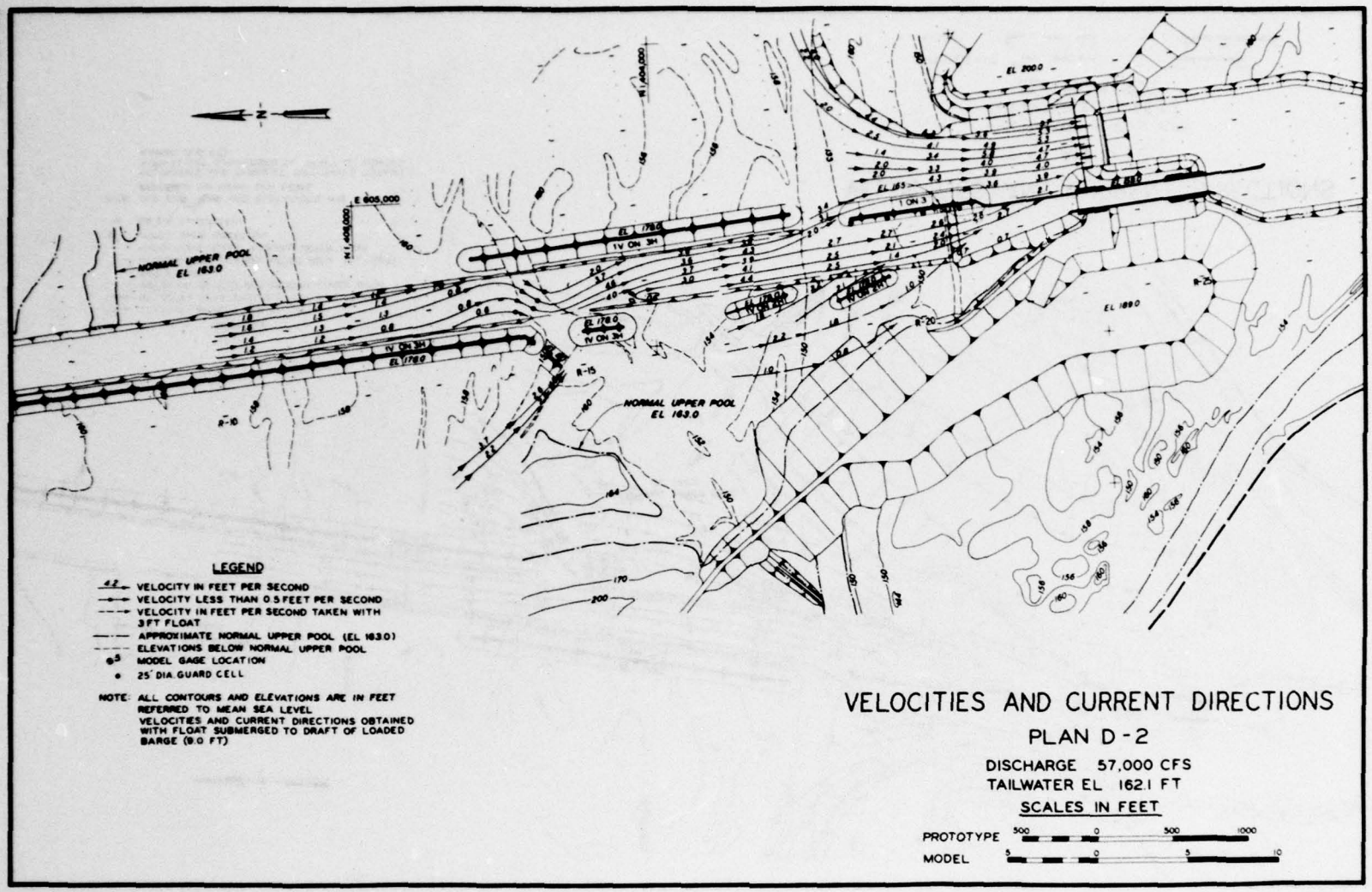
SCALES IN FEET

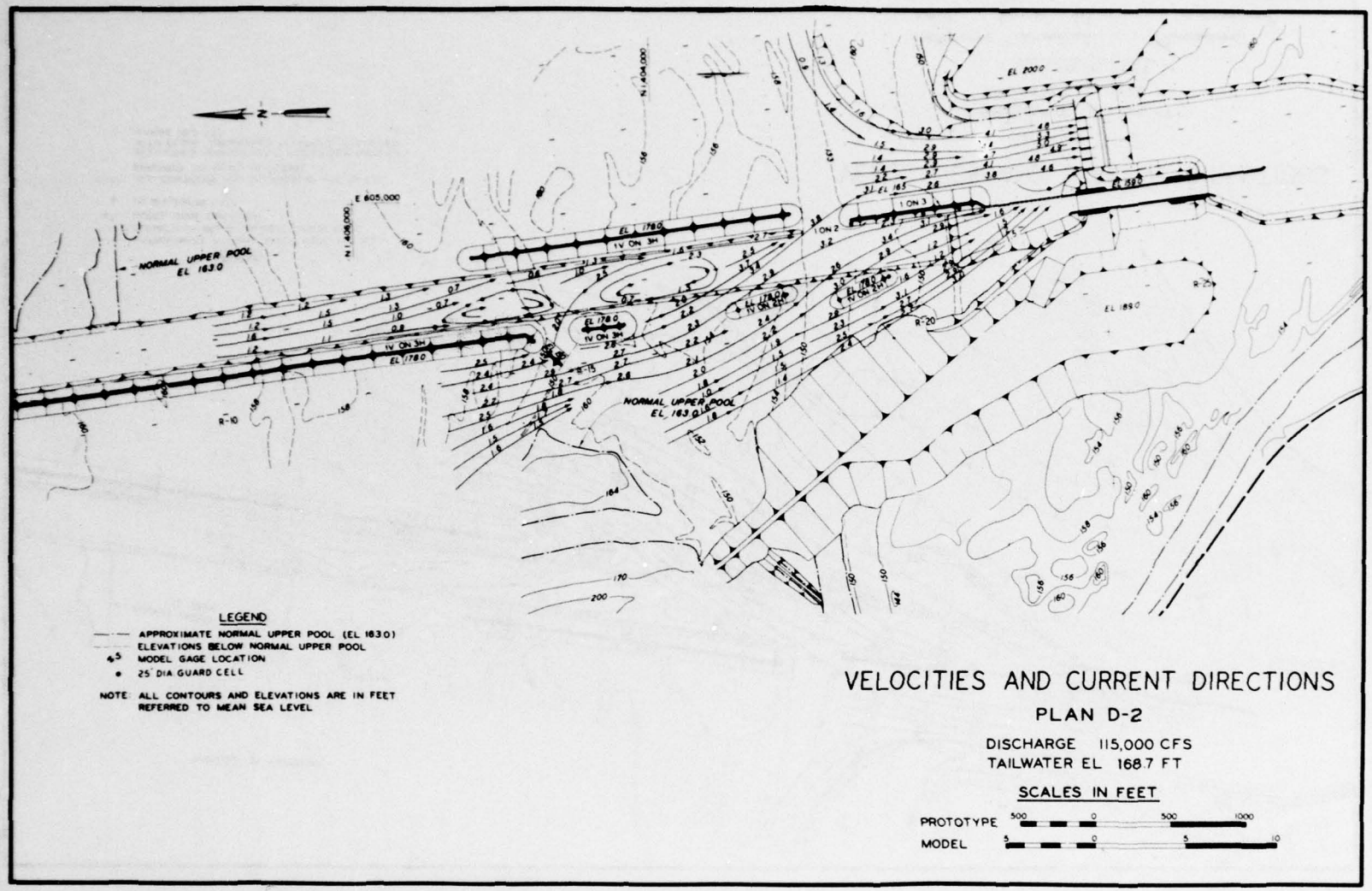
PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

PLATE 19

PLATE 20


N
E 805,000
N 1,409,000
N 1,404,000
NORMAL UPPER POOL
EL 163.0
EL 178.0
1V ON 3H
1 ON 3
EL 185
EL 200.0
EL 189.0
R-10
R-15
R-20
R-25
LEGEND
42 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
VELOCITY IN FEET PER SECOND TAKEN WITH 3FT FLOAT
APPROXIMATE NORMAL UPPER POOL (EL 163.0)
ELEVATIONS BELOW NORMAL UPPER POOL
MODEL GAGE LOCATION
25' DIA GUARD CELL
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
VELOCITIES AND CURRENT DIRECTIONS
PLAN D-2
DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



VELOCITIES AND CURRENT DIRECTIONS

PLAN D-2

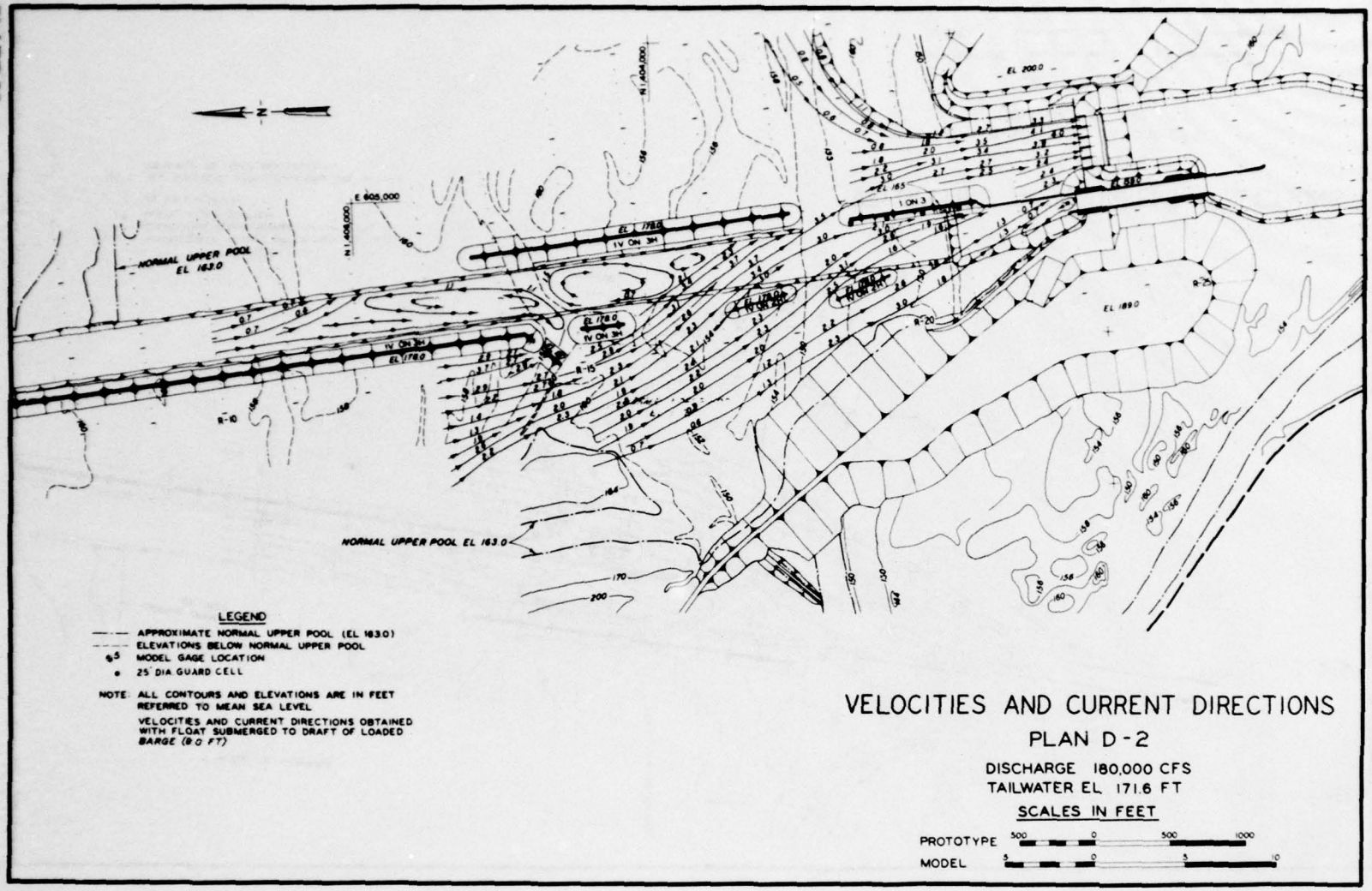
DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 21

PLATE 22



LEGEND

- APPROXIMATE NORMAL UPPER POOL (EL 163.0)
- ELEVATIONS BELOW NORMAL UPPER POOL
- MODEL GAGE LOCATION
- 25' DIA GUARD CELL

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

VELOCITIES AND CURRENT DIRECTIONS

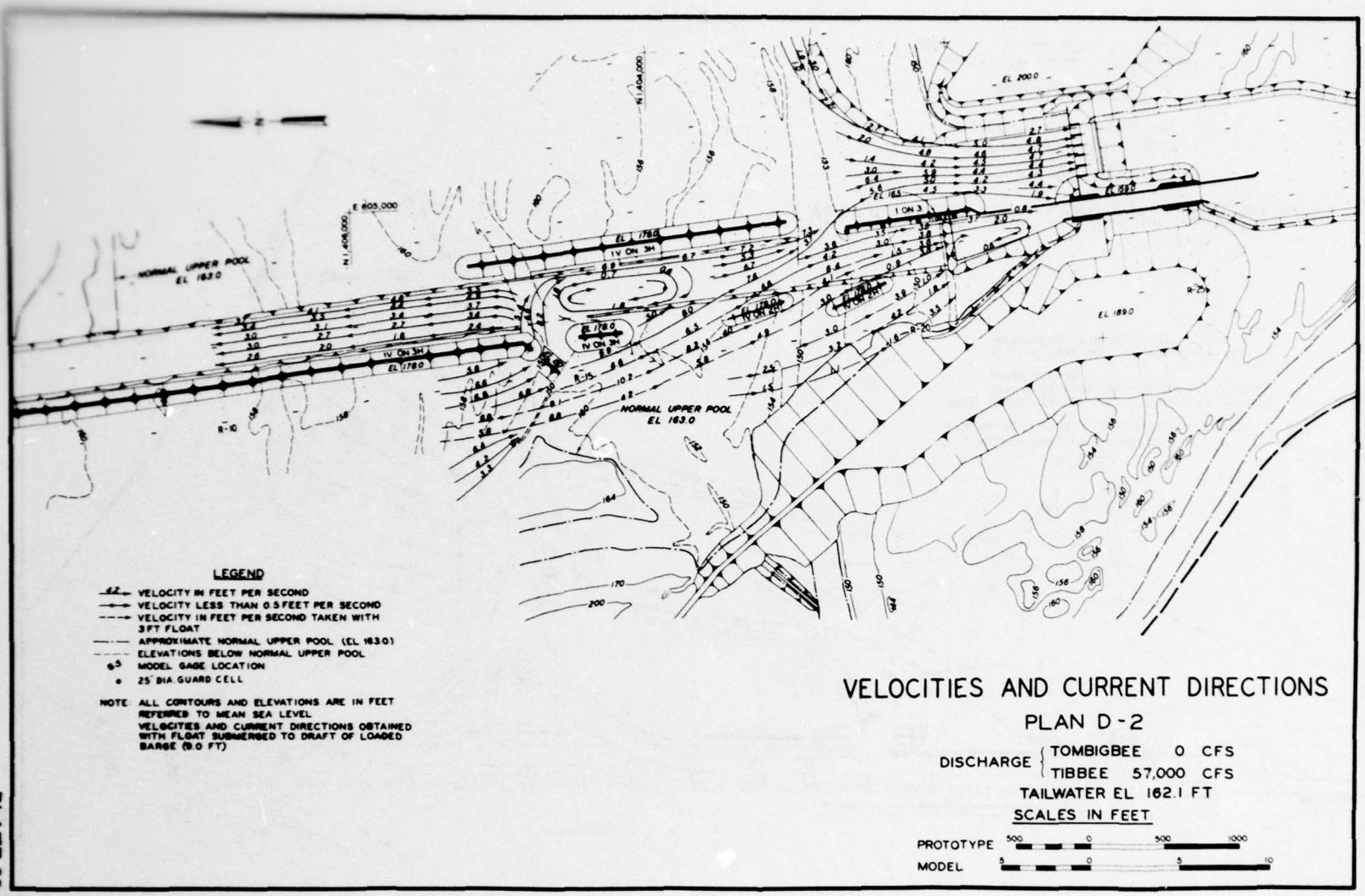
PLAN D-2

DISCHARGE 180,000 CFS
TAILWATER EL 171.6 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



VELOCITIES AND CURRENT DIRECTIONS

PLAN D-2

DISCHARGE { TOMBIGBEE 0 CFS
TIBBEE 57,000 CFS

TAILWATER EL 162.1 FT

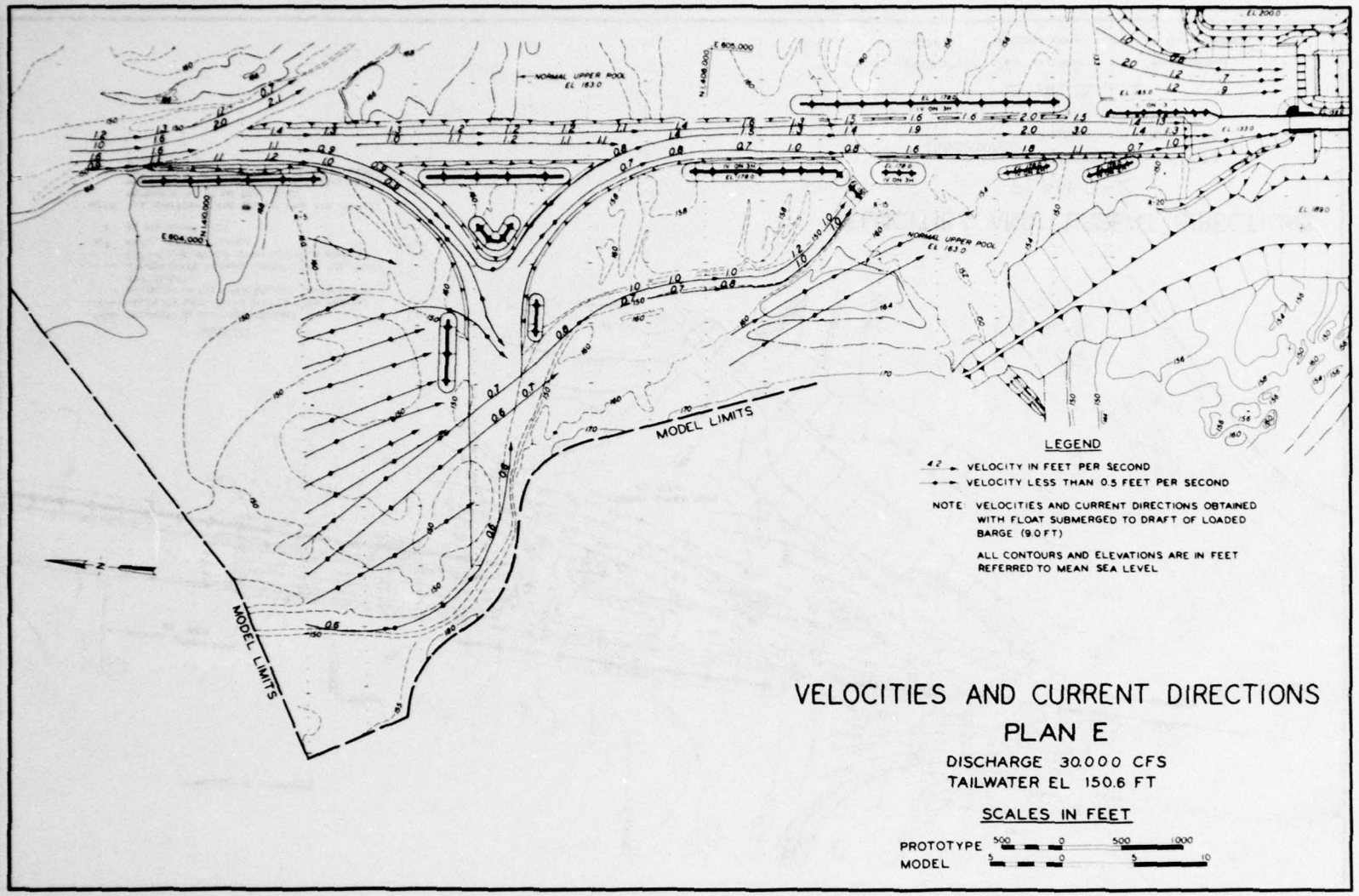
SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

PLATE 23

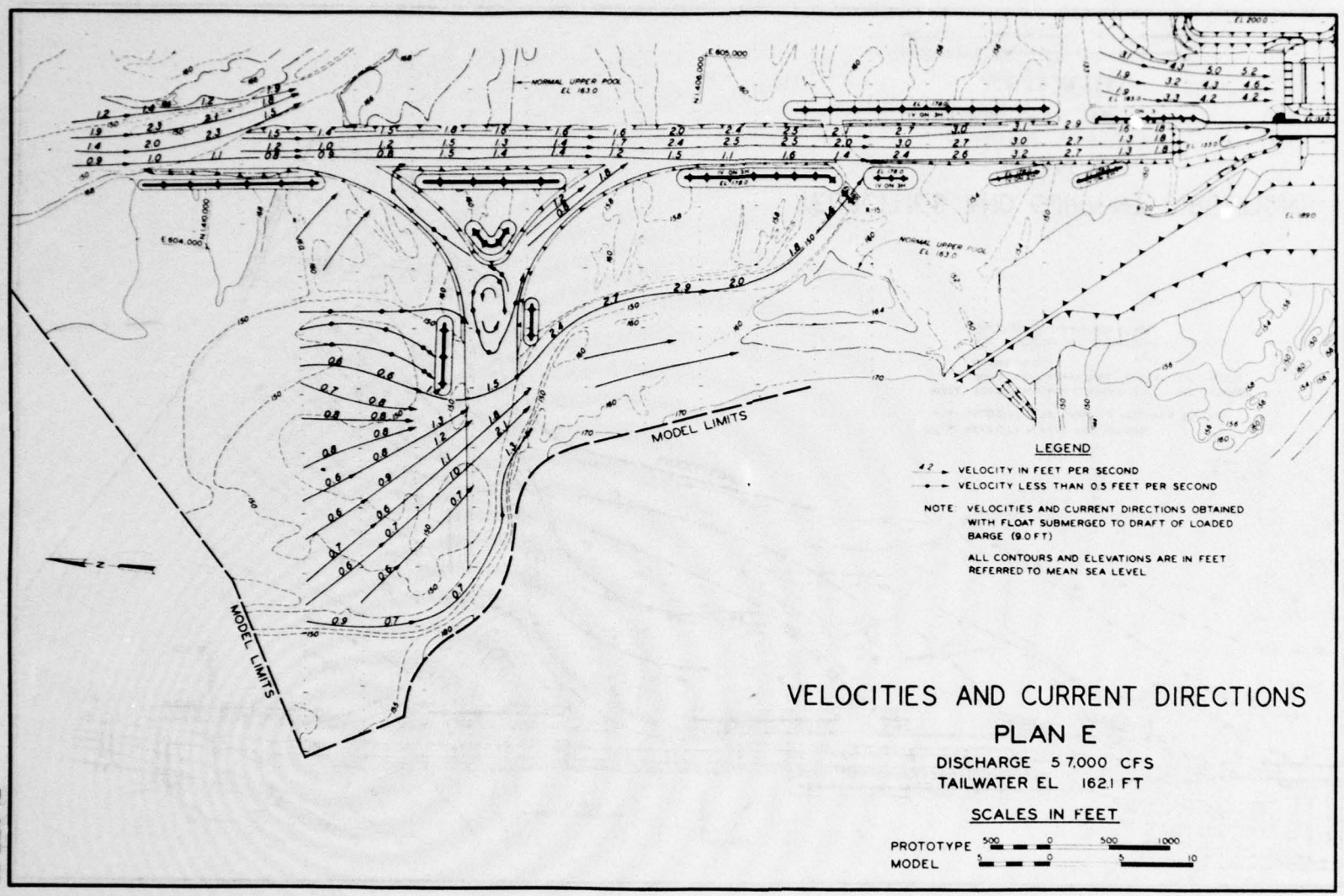
PLATE 24



VELOCITIES AND CURRENT DIRECTIONS

PLAN E

DISCHARGE 30,000 CFS
TAILWATER EL 150.6 FT



VELOCITIES AND CURRENT DIRECTIONS

PLAN E

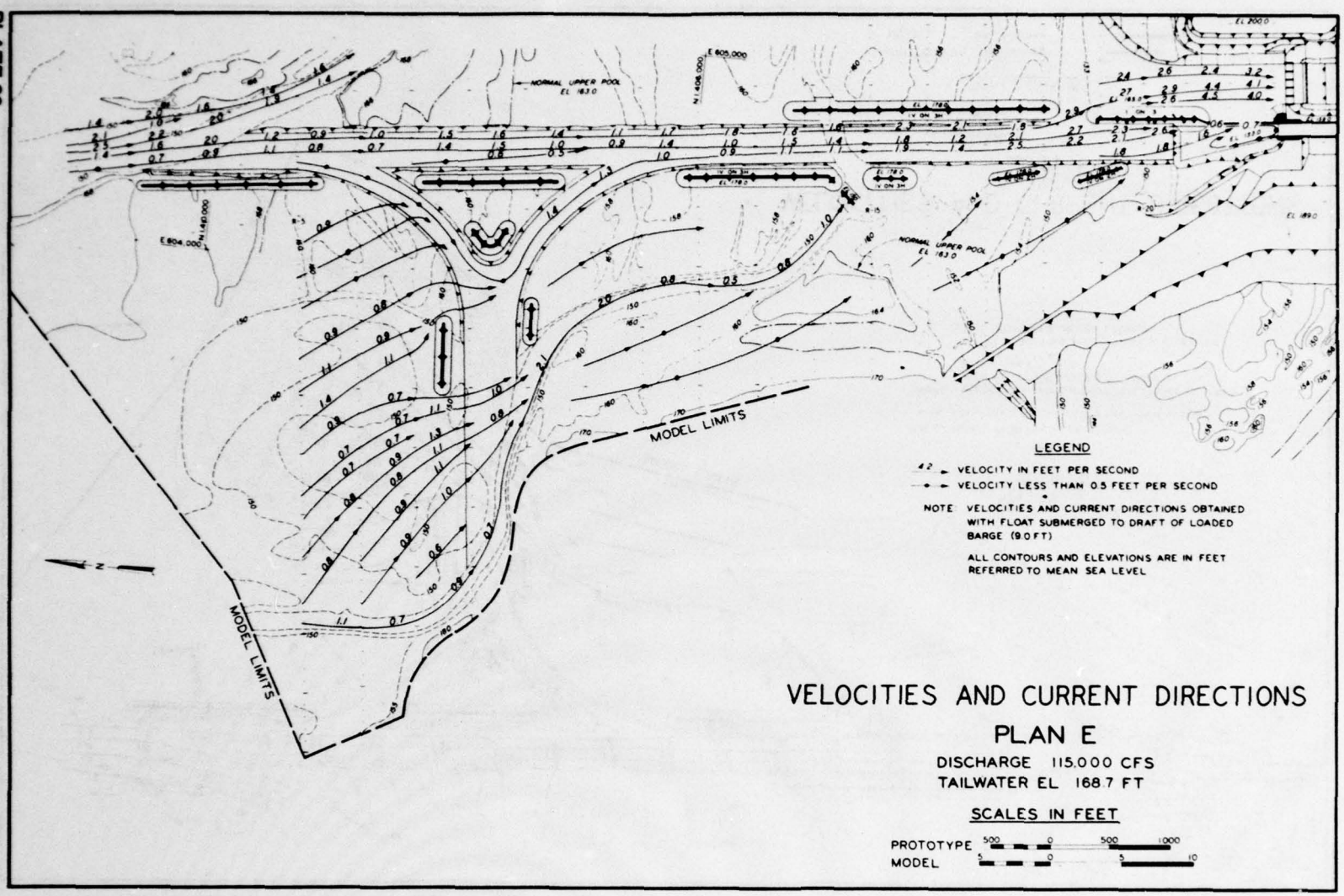
DISCHARGE 57,000 CFS
TAILWATER EL 162.1 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 25

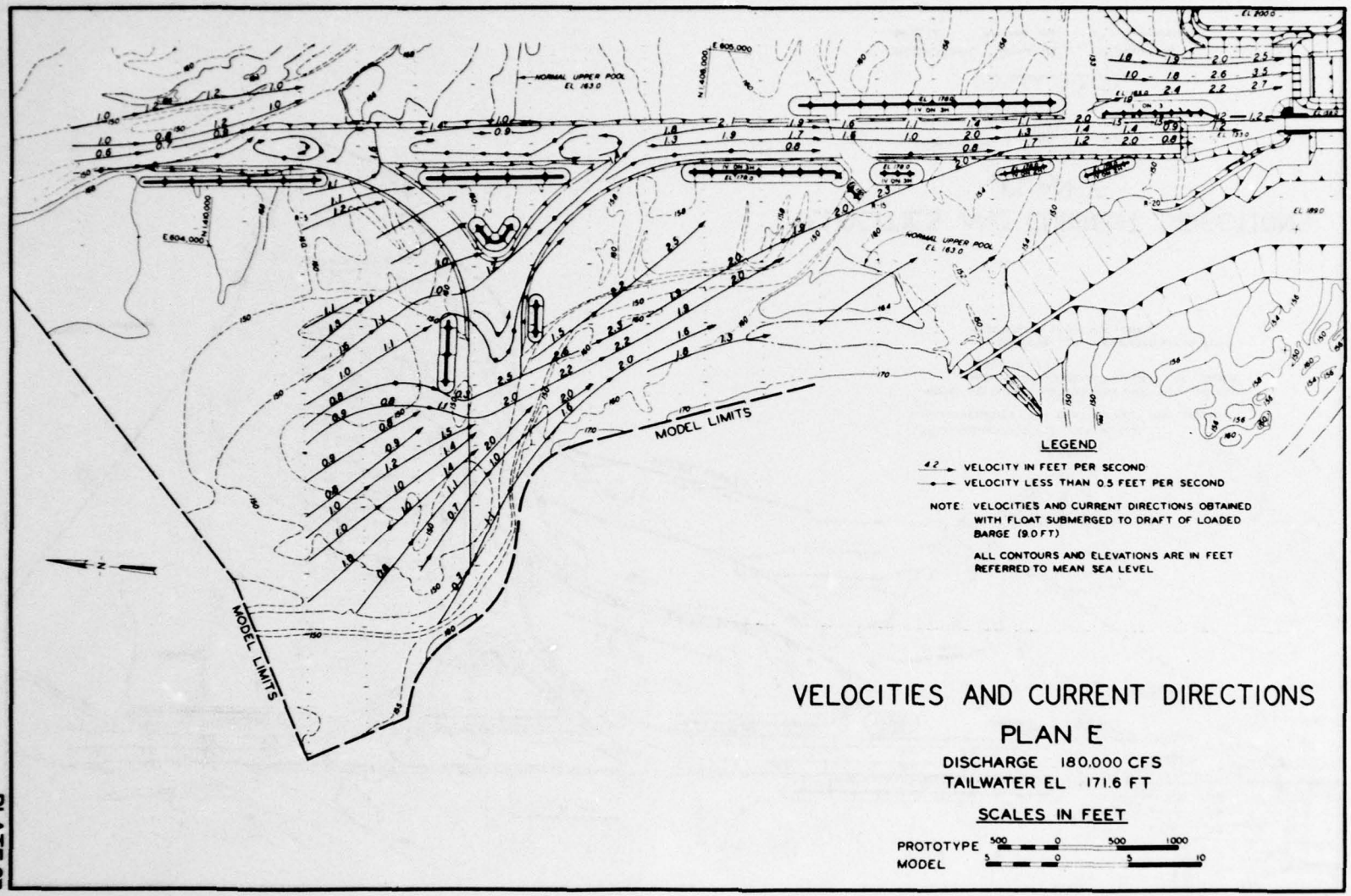
PLATE 26



VELOCITIES AND CURRENT DIRECTIONS

PLAN E

DISCHARGE 115,000 CFS
TAILWATER EL 168.7 FT



VELOCITIES AND CURRENT DIRECTIONS

PLAN E

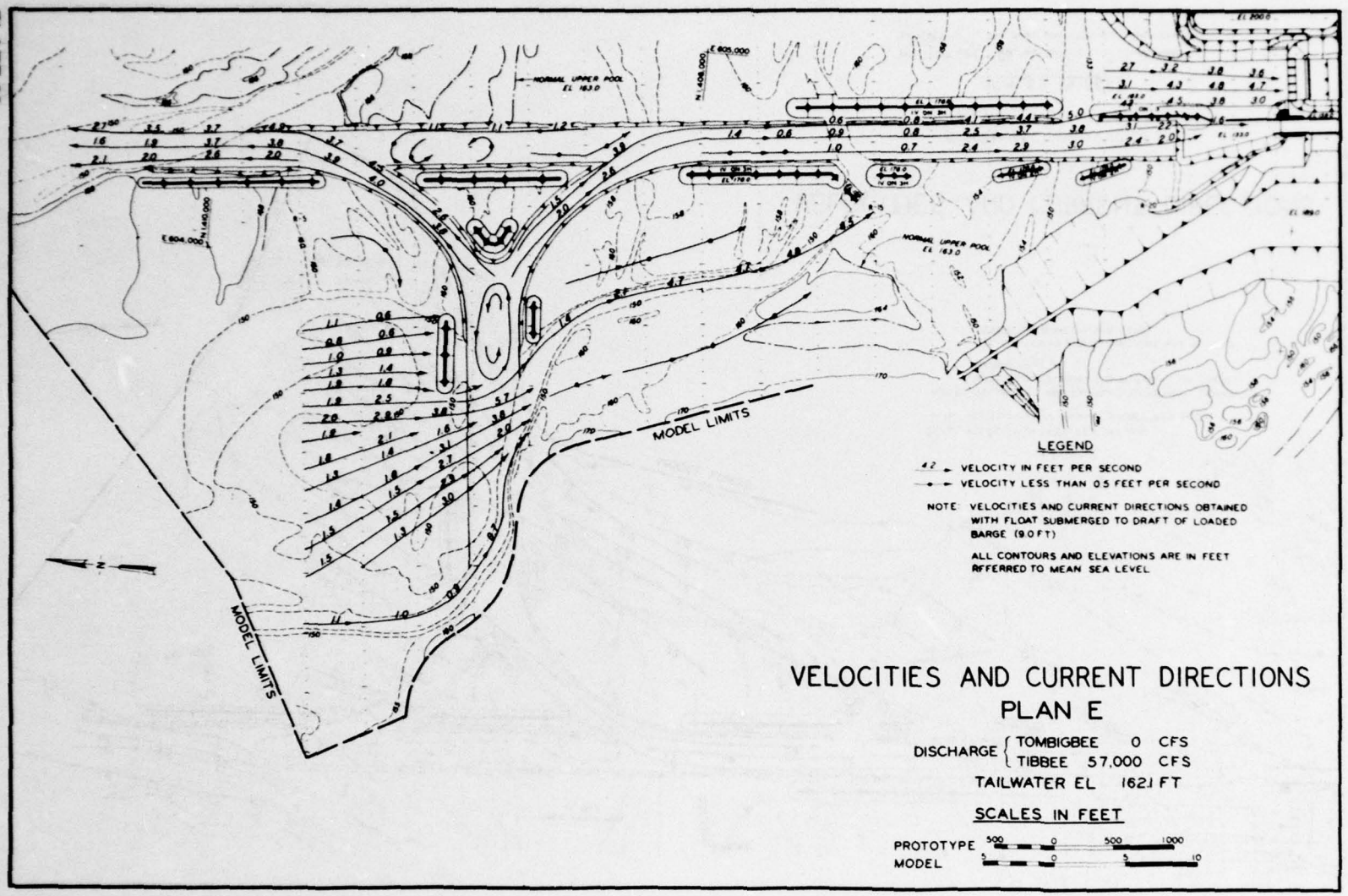
DISCHARGE 180,000 CFS
TAILWATER EL 171.6 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 27

PLATE 28



VELOCITIES AND CURRENT DIRECTIONS
PLAN E

DISCHARGE { TOMBIGBEE 0 CFS
TIBBEE 57,000 CFS

TAILWATER EL 162.1 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Franco, John J
Navigation conditions at Columbus Lock and Dam, Tombigbee River, Mississippi and Alabama; hydraulic model investigation, by J. J. Franco [and] L. J. Shows. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1977.
1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Technical report H-77-11)
Prepared for U. S. Army Engineer Division, South Atlantic, Atlanta, Ga.

1. Columbus Lock and Dam. 2. Hydraulic models. 3. Locks (Waterways). 4. Navigation conditions. 5. Navigation dams. 6. Tombigbee River. I. Shows, Louis, J., joint author. II. U. S. Army Engineer Division, South Atlantic. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Technical report H-77-11)
TA7.W34 no.H-77-11